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THE BURIED CITY OF CEYLON.

By JOHN M. ABBOT.

COMPARATIVELY few people outside of Ceylon realize that on that little island in the Indian Ocean was once a civilization which when Christ was born was at its height. After all these centuries little of it remains except a few imperfect ruins of its most famous city, Anuradhapura.

At one time, about 200 B. C., this was the capital of the island. No estimate of its population has ever been made, but some idea of its size can be gathered from the fact that it harbored 96,000 Buddhist priests. In area the city occupied about 100 square miles, and it was divided into two parts, the inner, wherein are the remains of the temple and the monasteries, and the outer, where lived kings and the laymen.

The city was built in the wave of religious enthusiasm which struck Ceylon with the advent of Buddhism. Successive kings vied with each other to erect monuments worthy of themselves and their faith. But the hand of time and successive invasions by the Hindoo Tamils, who took pleasure in destroying what they could not replace, have left of this once mighty city of Anuradhapura nothing but a few granite posts in the thick jungle.

Thirty years ago these even were not visible, but from the Mahavansa, the one literary document in Singhalese history running from B. C. 542 to nearly our own day, the site of the ancient city was known, and so the British government set about the work of excavation. The greater part of the city was found about six or eight feet underground, and it is hard to realize that nature alone has accomplished this task.

VILLAGE SCENE IN CEYLON, NEAR ANURADHAPURA.

Illustrations from the National Geographic Magazine.

THE ROCK TEMPLE, CARVED OUT OF SOLID ROCK, POLLONNARUWA, CEYLON.

Two thousand years ago the city was situated on a fertile plain. Water was brought from the mountains, forty miles distant, in a huge canal and stored in large artificial lakes, from which it was distributed to tanks in various parts of the city. One of the first acts of the Tamils was to destroy this system of irrigation, and with that ended the prosperity which the country had enjoyed. For four months of the year Ceylon is deluged by rains; for the rest of the time there is practically a drought. The tanks and lakes served the same purpose for which the great dam of Egypt has been constructed — to keep back the water in time of plenty for use in time of need. Agriculture was brought to a standstill, and it was only by practically replacing these ancient works that the British government has made cultivation in this district possible.

The Tamils destroyed the city, and Nature completed the work by concealing the remains. Like Jerusalem after its final destruction, not one stone remained above another.

The most imposing objects in Anuradhapura are the Dagobas, of which there are four. They are huge mounds of solid brick shaped like beehives and from three to four hundred feet high. They

(*Continued on p. 26116.*)

THE FIGHT AGAINST YELLOW FEVER.*

By A. Dastre.

Once again yellow fever claims our attention. While we are celebrating the victorious effort of science in driving that dread disease from its hereditary domains in Havana and Rio Janeiro, it reappears and desolates New Orleans; it revives in Honduras and threatens Panama. Once more we must fight to renew the achievements of the Americans in Cuba and of the Brazilians in Rio. And that is possible, for we can struggle to-day with hope, with certainty of success. For centuries the disease remained unconquerable. Physicians knew only what everybody sees—the external signs—the symptoms and fatal results, but they were not familiar with the true nature of the disease and the manner of its propagation.

In fact, even to-day our knowledge of the nature of the evil is very elementary; we have few facts concerning the micro-organism of yellow fever. The only proven point is that it is a blood parasite, not feeding upon the red corpuscles like the parasite of malaria, but only upon the fluid part—the "plasma." It is believed that it does not affect the transparency of liquids, that it can penetrate most filters, and that it remains invisible to the microscope.

But if the deadly agent, the ultramicroscopic germ, which is the specific cause of the disease, is not well known, we are at least familiar with the means of its propagation, the sole agent of its transmission, and that is sufficient, as we shall see, rationally and effectually to eliminate contagion.

This definite agent, the only one capable of inoculating a man with the micro-organism of yellow fever, is a particular species of mosquito, the *Stegomyia fasciata*, known also as *Culex calopus* and previously called *Culex fasciata*. At the time of Linné, in 1758, only six species of mosquitoes were known. In 1902 two hundred and fifty different species could be distinguished, and the number has since increased to nearly four hundred described species. The English naturalist, F. V. Theobald, an authority on the subject, recognized twenty-nine genera. To one of these he gave the name *Stegomyia* (fly which hides), and in this new genus he established twenty-two species. It is one of these species, the *Stegomyia fasciata*, which to the exclusion of all others, transmits the yellow fever parasite from the sick to the healthy man. This Stegomyia, moreover, is the most cosmopolitan of all species of mosquitoes, and its wide distribution explains the continuous spread of this terrible malady since the discovery of America.

Before entering into the blood of a man the fever germ must have passed a period of incubation in the tissues of the mosquito, and *vice versa*. This is a fact of prime importance. The sickness of man implies the sickness of the mosquito, and inversely. The mosquito's illness, however, is light, scarcely perceptible, while that of man is severe. If ever the human race arrives at the point of being freed from the yellow fever micro-organism, the *Stegomyia fasciata* will be freed at the same time. Thus there is a sort of pathological compact between man and the mosquito, a kind of unhealthy fellowship, of which the existence of this infectious bacillus is the binding force. We may therefore believe that in order to eradicate this plague—that is, the parasitic microbe—this fellowship must be dissolved. The healthy man must be isolated from the infected mosquito and the healthy mosquito from the infected man. There would be no danger in the contact of a healthy man with a healthy mosquito. That is the theoretical idea. The practical sanitary scheme follows this formula: To drive out the mosquito, to kill it, or to make it well. Only by accomplishing separately one of these three aims, or all three at the same time, have the sanitary authorities been successful in making healthy the island of Cuba, the Brazilian coast, and more recently the territory of Dakar, in the French West African colony. Success has been attained in purging these regions of the disease which had existed there in an endemic state, and in stifling at the start epidemics threatened by imported infected cases. It is the same line of action that will have to be followed in every locality at each reappearance of the disease until humanity is entirely freed from it.

But to avoid the mosquito, or to find shelter from its bite, we must know its mode of life, its customs, its habits, its peculiarities, or, in a word, its complete life history. And that is just what we have learned from numerous researches by medical naturalists, among whom must be named the members of three commissions organized by the United States, English, and French governments and sent to the infected localities to study on the spot the evil and its remedies. Mention must also be made of scholars from the Colonial Medical School of Liverpool and from the Institut Pasteur de Paris, who have directed these studies and summarized the results. Besides special memoirs, the perusal of which is incomparable to gain a knowledge of the subjects, several recent publications of a more general character have offered the scientific public a collective view of the ideas gained. Among these works special mention should be made of Dr. Raphael Blanchard's elaborate volume upon the natural history of mosquitoes and their relation to medicine, and of the excellent little book of Messrs. Chantemesse and Borel upon the yellow fever mosquito.

Through these documents, traced to their different sources, I shall explain, not so much the practical methods employed in the struggle against yellow fever as the scientific theories upon which the defense is based.

* Translated for Report of Smithsonian Institution from Revue des Deux Mondes.

I.

The history of yellow fever epidemics in various epochs shows a remarkable tendency for the disease to extend its ravages. Originating in the islands and on the coast of the Gulf of Mexico, it remained for a long time bound to its birthplace. At Vera Cruz the Spanish conquerors waged war against it from their first attempts to conquer Mexico at the beginning of the sixteenth century. It was as formidable an enemy to them as the Aztecs. Historians of the conquest record that the band under Diego de Nunes, numbering 780 men when in 1509 it had just taken possession of the lowlands of Vera Cruz, lost 400 men in a short period, and fifteen months later their number was reduced to 60 men. This first disaster was significant. It announced to invaders the frightful consumption of lives of Europeans which this minotaur of the Tropics, known as the yellow typhus, black vomit, or yellow fever, was to make during four centuries.

All along the coast of the Gulf of Mexico, at the mouths and on the banks of rivers, the disease lived in an endemic state, showing at long intervals periods of epidemic outbreak more or less violent. From this permanent center, called the "Mexican source," there extended numerous epidemic radiations. Several, mounting toward the north, attacked the Bermuda Islands and the Atlantic coast of the United States; others, summering in the south, infected the Guianas and Brazil; then encircling the South American continent, set upon the Pacific ports. Sugar-laden vessels from Cuba carried the contagion to the maritime cities of Europe. In the eighteenth century slave ships returning from the Antilles infected the western coast of Africa.

Most of these epidemics, emanating from their original Mexican center, were extinguished in the spot only after disastrous ravages. But at other times the yellow fever, encountering in the new countries conditions favorable for its development, established itself permanently in an endemic state. This is what happened in Brazil and on the coast of Africa.

Thus were established two secondary sources which became in their turn two new centers of radiation—the Brazilian source and the African source. This African source, which dates, as I have said, from the middle of the eighteenth century, is located in the Gulf of Guinea between the mouths of the Niger and the Congo. It is particularly in the region of Sierra Leone that the permanent endemic character of the infection is clearly manifest; from here have radiated most of the epidemics which have ravaged Africa.

The Brazilian source is of more recent date; it was established in the middle of the nineteenth century. In 1849 a single ship from New Orleans, the "Brasil," brought yellow fever to Bahia. From that city another vessel, the "Navarre," carried it to Rio Janeiro, where it found all the conditions necessary for its naturalization—a low, marshy ground, river deposits, an intense heat, and an excessive humidity. So the disease took permanent root as an endemic; it became a national disease. Finally it branched out from this new center toward the interior countries, following, as usual, the courses of rivers. Thus was produced the epidemic which in 1870, during the war waged by Brazil against Paraguay, broke out in Assumption, on the Parana, 1,200 kilometers from the coast, and with 30,000 victims spread as far as Buenos Ayres.

Europe in its turn has been the object of many repeated attacks by this terrible plague. The southern countries below the forty-third degree of latitude have especially suffered. Spain was attacked for the first time at Cadiz in 1700. The same port was infected from 1730 to 1734, then in 1780, again from 1800 to 1804, and from 1810 to 1812. The epidemic of 1800 to 1804 instead of being confined to regions along the coast climbed the course of the Guadalquivir and gained the interior country; it spread to Andalusia and fell upon Catalonia, with a total of 80,000 victims. In 1812 Barcelona was infected by the ship "Grand Turc," hailing from Havana, and 20,000 persons perished. Another epidemic broke out in Passages in 1828. From this date there is nothing to mention except two relatively mild incursions of the plague—one in Barcelona in 1870, the second in Madrid in 1878 upon the return of a Cuban regiment. Portugal was seriously attacked at Lisbon in 1723, and lightly in 1750 and 1751. In 1856 Oporto was the seat of an important epidemic which, brought by two ships from Brazil, killed 7,000 persons. Italy, since it has little maritime relation with the centers of contamination, has remained almost entirely free from the plague. Nevertheless in 1804, at the time of the Spanish epidemic, contagion spreading from Barcelona to Livorno caused the death of 1,500 persons. In 1883 a patient arrived at Torre Annunziata and became the center of a slight spread of yellow fever.

So much for the hot countries of Europe. In the more temperate regions of France and England north of the forty-third parallel there have frequently been yellow-fever cases imported by ships, but never a real epidemic.

In France the ship quarantines of Marseille and of Brest received patients afflicted with yellow fever in 1802, 1804, 1807, 1821, 1836, 1839, and later, nearly every year from 1891 to 1900. In each case the workmen employed in unloading the vessels were infected, but there was no contagion ashore.

The incidents at Marseille in 1821 and at Saint-Nazaire in 1861 are especially interesting; Messrs. Chantemesse and Borel have shown how instructive they are. While Spain was violently infected during the summer of 1821, a brig, the "Nicolino," left the port of Malaga bound for Marseille. Upon the day of its departure, August 26, a yellow fever patient died on board. During the trip a second case broke out, and on September 7, upon the ship's arrival in Marseille, the patient was sent to the hospital at Pomegue and the vessel held in the quarantine basin. Other vessels to the number of 40, hailing from such countries as Tunis, Cyprus, and Alexandria, where yellow fever had never existed, were moored along the quays of the basin and kept strictly apart without the least contact with each other. Nevertheless cases of yellow fever broke out around the brig, even in the quarantine basin. From September 7 to October 2, twenty-two persons were infected. These were some sailors on the neighboring ships, some health officers stationed on board for their surveillance, and a laborer working on a pontoon anchored a short distance away.

It was a matter of surprise that the disease so contagious on shipboard and in its immediate vicinity was not contagious from the patients transferred to the hospital, nor, as in the case of the workman, in their houses in the city. No case of contagion in fact originated either in the hospital or in the city. It is not, then, the sick man himself nor his clothing, nor his linen, that are the vehicles of the disease, nor even the shrouds of the deceased ones, but the vehicles are the mosquitoes, the Stegomyia, household insects, which of their own accord wander no more than a few hundred yards from their birthplace. In the present instance the breeding place of the infectious mosquitoes, their home, was the obscure corners of the ship "Nicolino."

The epidemic of Saint-Nazaire in 1861 furnishes an analogous example. The ship "Anne-Marie" sailed from Havana June 12 and arrived at Saint-Nazaire July 25. Nine sailors were attacked with yellow fever during the voyage, but they had recovered. The ship's sanitary condition being good it was admitted to port. They opened the hold, the haunt of the insects, a veritable box of Pandora. They unloaded the cargo and proceeded to make repairs. Presently some cases of yellow fever developed among the workmen, the mechanics, the people dwelling in the vicinity of the infected ship. From July 25 to August 16, twenty-one individuals were attacked. The epidemic of which the "Anne-Marie" was the center spread to the neighboring vessels, and ten new cases broke out more or less tardily after they had left port.

England is in the same condition as France in respect to yellow fever. The ports of Falmouth, Southampton, and London have had several outbreaks of the disease. Epidemics may originate on a contaminated ship, carrying in its hold some Stegomyia. These insects, either infected when the ship sailed or susceptible of infection from yellow fever patients during the voyage, transmit the disease to whoever approaches them. Some mosquitoes pass to ships near by and make them new centers of the disease. That is the story of the epidemic of Saint-Nazaire in 1861. It is likewise the history of the epidemic that occurred four years later at Swansea, England, where the ship "Hecla," arriving from Cuba, contaminated a score of persons coming aboard and spread the fever to another vessel anchored in its vicinity.

This is not the place to give a story in detail of all epidemics. It is enough to say that all the particular circumstances are clearly explained by the supposition that the mosquito is the sole agent of propagation of the infectious germ and by the knowledge of its mode of life, its habits, and its dwelling places.

II.

What has been said of the geographical distribution of yellow fever has shown the tendency of the disease to spread continuously on land. It is seen that its progress has been steady since the beginning of the sixteenth century. Can we tell where its onward march will stop unless scientific hygiene intervenes to cut it short? Should we suppose that it will continue indefinitely and that the pest without cessation will overrun new regions as navigation is developed and as commercial relations are multiplied with contaminated countries? Finally, what are the countries menaced in the more or less near future?

It is easy to answer these questions. It is enough to translate the statement into a language conforming to the doctrine of propagation of the disease by the mosquito. The yellow fever will be implanted wherever the Stegomyia lives and multiplies, or better, wherever it is capable of living and multiplying. By a happy chance for European countries it is found that this species of mosquito can live only in conditions of high temperature, exactly adapted to the accomplishment of its vital functions. The perfect insect can subsist only at a temperature between 60 and 100 deg. F.; below 60 deg. it is paralyzed, benumbed, it dies; at 65 deg. it moves with difficulty. It bites with energy only above 75 deg. It mates between 68 and 85 deg., but there is fertilization only when the temperature is above 75 deg. It lays its eggs in the water where it lives, in stagnant water of flower vases, gutters, bottles, tubs, and sinks, but only when the temperature is from 80 to 85 deg.

The conditions of development of the larvæ are not less rigorously precise. The development of the egg and the hatching of the larva demand a temperature between 68 and 85 deg.—the best is at 82 deg. All lowering under that figure shows itself by a greater or less retardation in their development. The larva is aquatic. Its respiration of air obliges it to fix itself at the surface of the water or to rise there to seek the air periodically. It develops normally into a perfect insect in a period of nine days, provided the temperature at night does not go below 80 deg.; otherwise the formation of the winged insect capable of mating and

of reproducing itself, is prolonged to forty or even sixty days.

To sum up, then, it appears that the yellow fever mosquito obtains its full and regular vital development only at an average temperature of 82 deg., and that any lowering of the temperature night or day renders less efficient some one of its physiological functions. This data is consequently of the first importance. The strict dependence of the mosquito on temperature conditions is an essential fact in the interpretation of the history of yellow fever; it is the key to all its mysteries. The Stegomyia needs plenty of heat and of heat steadily maintained. As soon as the temperature falls, the insect's life becomes endangered, and at 60 deg. it is benumbed and soon dies. This sensitive insect does everything in its power to protect itself from the increasing chilliness of the air, and its mode of living offers the means for doing so. It is practically a fellow-boarder with man, under the same roof. It is a domestic animal, like the house fly. Whenever it is cold, it takes refuge in kitchens, bathrooms, heated bedrooms, in bakeries, or in other warm places. On ships it finds a last resort close to the engine room, near the heat pipes or smoke pipes. If the temperature falls below 60 deg., it becomes torpid and benumbed like a marmot.

These conditions in their rigorous precision are, so far as known, peculiar to the Stegomyia among all mosquitoes, and explain many features in the history of yellow fever. I shall mention but one. This relates to the peculiar immunity enjoyed by the inhabitants of Petropolis, in Brazil. Petropolis may be called the sanitarium of Rio Janeiro. It is a country resort 30 miles from the capital, at an altitude of 2,800 feet. It is the residence of the well-to-do population—the diplomatic corps, the principal merchants, financiers, and government officials. Before nightfall all these take the tram for the elevated region, where they find bracing air and healthful security. Petropolis, in fact, is free from yellow fever at the very time when Rio is scourged with it, and yet between these two places there is a lively traffic and constant relations. Even more, some yellow fever patients are taken there for treatment throughout their illness, yet the disease is not communicated to anyone. The reason is that the Stegomyia can not live in that climate, and such as come in the railway trains each day perish immediately, for the evenings are cool and during the night the temperature often falls below 60 deg. There is sometimes another explanation given for the immunity from fever enjoyed in this Brazilian country resort. It is attributed to the altitude of the region above sea level. This is a mistake. Yellow fever and its mosquito are found even at greater heights than Petropolis. It is enough to mention the epidemic at Morne Rouge, in Martinique (920 feet elevation); at Camp Jacob, in Guadeloupe (1,800 feet); at Newcastle, in Jamaica (4,000 feet). The fact is that thermometric conditions are paramount.

It is found that the extreme heat and humidity best adapted to the welfare of the yellow-fever mosquito are most common along the coasts of tropical countries. The lands best suited to the swarming of this insect and to the spread of the plague form a belt around the earth north and south of the equator. If lines be drawn in the northern and southern hemispheres corresponding to the forty-third parallel of latitude, the circles would mark the upper and lower limits of the home of the Stegomyia and, accordingly, of the yellow fever. The regions comprised in this vast zone form what MM. Chantemesse and Borel call the "infectible territories," and the more temperate countries on either side of this zone, denied to the mosquito, are the "uninfectible territories." The *Stegomyia fasciata* considered as a species cannot become acclimated beyond this equatorial zone, for it does not find that almost invariable temperature of 82 deg. which is indispensable for the proper exercise of its vital functions, and especially of reproduction.

The infectible zone represents the actual or virtual habitat of the infectious mosquito. It is the region of epidemics and is also the region of possible endemic or permanent centers of infection. At present the Stegomyia, which is a genus of mosquito very cosmopolitan in its habits, lives in widespread districts throughout the infectible zone. Theobald found it in India, the Malay archipelago, in Japan, in Africa, in America, and in all warm countries where he hunted for it. The contagion is capable, if not well guarded, of spreading over a very large part of the warmer portion of the inhabited globe. Thus, if an infected vessel, having on board men or merely mosquitoes contaminated with the disease, makes a landing in the infectible zone, it threatens a whole country with an epidemic; men inoculate the Stegomyia, and new generations of Stegomyia carry the disease to other men; the plague progresses, the contagion spreads in scope and in duration; the port, the city, the country is ravaged. This is what happened in Spain at the time of the epidemic at Cadiz and at Barcelona in 1804 and 1812.

The case is totally different in the uninfectible territories situated beyond the habitat of this mosquito. The infected vessel occasions only a local epidemic, which exhausts itself on the spot. The infectious insects, on account of their sedentary habits, never wander far from the ship that houses them; they bite only those imprudent enough to disturb them. At the farthest they move only to the neighboring vessels. Since the climate is unfavorable for their reproduction, their ravages last only during their ephemeral life. Hence these minor epidemics are limited to a single ship or to an anchorage basin and vanish of their own accord. This was the case with the yellow-fever invasion observed at Marseille, at St. Nazaire, at Swansea, and in general at all French and English ports. The reason for this is understood. It is because all of England and nearly all of continental France are beyond the forty-third parallel, and consequently the disease does not flourish there.

III.

This line of demarkation between the countries that are susceptible of infection and those which are not, a line fixed by the forty-third parallel, has much importance in the campaign against the yellow fever. On one side of the boundary the peril is great, and sanitary measures should be rigorous. On the other side there is, so to speak, no danger at all, and the subject of sanitation is very much simplified. On either side of this entomological and pathological frontier the health regulations may, and should, differ. They should be made in accordance with scientific facts, which enlighten both theory and practice. How the obscurities disappear! How the paradoxes vanish that troubled investigators just a few years ago! The physicians in the Marseille quarantine during the epidemic of 1821 understood nothing of the nature of that disease which was so frightfully contagious on shipboard and which ceased to be so the moment patients were transferred to the city hospital. All is clear now that scholars on the United States commission of 1900* have taught us that there is no contagion from the infected persons, nor from their clothing, nor even from their fæces, but only by infected mosquitoes, which, in the case mentioned, were confined on a vessel. What a paradox it seemed to epidemiologists of that time that of two cities—Barcelona and Marseille—one clean and new, the other unsanitary and old, it was the first which was visited by the yellow fever, while the second remained untouched. There is no longer a paradox for those who know that one city is on the northern and the other on the southern side of the frontier that limits the habitat of the contaminating mosquito.

The forty-third parallel strikes the continent of Europe at Ferrol, in Spain, follows the Pyrenees districts, crosses the Hyères Islands below Marseille to the heights of Leghorn in Italy; it leaves below it nearly all of Spain, the southern half of Italy, and of the French possessions part of the Hyères Islands and of Corsica. Care should be taken in directing to any one of these islands any French colonial companies returning from yellow-fever countries.

The infectible countries, possible prey for the pestilence, comprise, as may be seen, a considerable enough portion of Europe, the whole of Africa, a large part of Asia, of Australia, and the oceanic islands. Here is an immense empire that must be watched. It will become more and more formidable, as direct relations are multiplied with the different endemic centers of Brazil, the Antilles, and the Gulf of Guinea. The cutting of the Isthmus of Panama, by opening to the plague Polynesia and the Asiatic world, might create a danger.

The way to prevent this extension is to attack the agent of its propagation, the Stegomyia, both on land and sea; on land by trying to purge the endemic centers where the insect becomes infectious, and on sea by attempting to destroy the mosquito itself in the ships where it finds refuge.

Three signal victories have been gained over yellow fever during these later years—in Cuba, in Brazil, and in Dakar, in West Africa. The first is the most memorable of these events. It is the purification of the endemic center at Havana. This occurred in 1901, during the United States occupation. The daily press in countless articles has spread the details. We know that Brig. Gen. Leonard Wood, governor of Havana, decreed one fine day that the plague should be wiped out and the mosquitoes destroyed throughout the entire city of Havana and its suburbs, and we know that it was done. Praise has rightly been given to the spirit of decision, of activity, of energy, and even Draconian rigor which attended the execution of this work. It remains to point out its wisdom, its exact conformity to scientific theories.

The theory was that the mosquito is the sole disseminator of the disease. This is precisely what the United States commission, appointed the year before, had just proven. It had shown that all the other supposed causes of contagion were imaginary; that a man could sleep in the bed of a sick patient or of one deceased, could come in contact with his fæces, put on his clothes, use his linen, confine himself in badly ventilated rooms at a humid temperature of 100 deg., and leave unscathed by the test if he escaped the mosquito bite. The extermination of the plague, then, leads to the extermination of the mosquito. But this pretension of banishing such a wily enemy seems foolish at first sight. You can hardly rid a room of one little insect that buzzes around, and yet they say you would rid a swampy country of legions of mosquitoes that abound there.

The yellow fever Stegomyia does not breed in swamps. It has not the habits of the Anophele of the marsh, the malaria mosquito. It does not live like that one, in the open country, but dwells in houses. It is a domestic insect. It stays at home, is wary, and is sensitive to the weather. Like many other mosquitoes, it never goes more than 500 or 600 yards away from its breeding place and journeys only when its home—a vessel or a carriage—journeys. There is no need to fear that the insect may be carried far by the wind, for it dreads the wind. It does not trust itself outdoors when there is the lightest breeze. The problem is thus simplified. It is no longer a question of protecting immense areas. It is enough to protect the house and its immediate environs—the city and a limited surrounding zone. Still it would be useless to capture the insect on the wing or at rest. It is permitted to complete its short life, but is not allowed to have offspring. The female is prevented from laying its eggs. This is accomplished by draining stagnant water left in so many gardens and household utensils where the mosquito seeks a breeding place. Hence the efficacy of the measures which forbade the people of Havana from keeping water in any other way than in covered receptacles or with a coat of oil or petroleum on top.

The success of the measures taken by the American physicians, Gorgas, Finlay, and Guiteras, in Havana was complete. Yellow fever has disappeared from there. On April 4, 1904, the President of the Republic of Cuba, in his message to the Congress, spoke thus:

"There has not been in Cuba since 1901 a single case of yellow fever not imported. The country should know of this excellent sanitary condition, which is due to the perfection of prophylactic measures and the vigilance of the health authorities."

Events happened in the same way in Brazil. Dr. Oswaldo Cruz, in charge of the organization of the campaign against yellow fever, with equal success repeated at Rio de Janeiro what had been done in Havana. The enforcement of the measures began April 20, 1903. The mortality which before had averaged 150 deaths a month fell to 8 in the month of April and to 4 in June. In January, 1904, there were recorded only 3 deaths.

France decided to follow these encouraging examples. The governor-general of French Western Africa, M. Roume, adopted an administration analogous to that of Havana and Rio de Janeiro, and he knew how to profit by these examples. The result was not long delayed. On May 29, 1905, an imported yellow-fever patient died in Dakar. Thanks to the precautions taken, this death has not been followed by a single other one. The threatened epidemic was stopped at its first stride and that colony saved from a new disaster such as it had suffered twice in less than thirty years.

* See Smithsonian Report for 1901, pp. 657-673; also biography of Dr. Walter Reed in present Smithsonian Report for 1906.

MODERN RIVALS OF THE TOWER OF BABEL.

Now that buildings are growing higher and higher and man is continually reaching skyward in his efforts to save space on the ground, it is especially interesting to see what was accomplished in the way of "sky-scraping" when there was none of the pressing need of economy of space which there is to-day.

A list of the monuments, towers, and buildings which are famous for architectural beauty as well as for lofty height follows:

	Country.	Feet.
Eiffel Tower, Paris	France	984
Washington Monument, Washington	United States	555
Cathedral at Ulm (the tower)	Germany	528
Pyramid of Cheops	Egypt	482
Strasburg Cathedral	Germany	468
Church of St. Peter, Rome (to top of cross)	Italy	435
Church of St. Martin, Landshut (tower)	Germany	432
Cathedral at Salisbury	England	404
Cathedral at Antwerp (the finished tower)	Belgium	402
Torrazzo Tower, Cremona	Italy	396
Cathedral at Florence	Italy	387
Park Row Building, New York	United States	387
Cathedral at Freiburg-im-Breisgau	Germany	386
St. Paul's Cathedral, London	England	364
Cathedral at Milan	Italy	355
Giralda Tower, Seville	Spain	350
Cathedral at Utrecht	Holland	338
St. Patrick's Cathedral, New York	United States	332
Tower of Asinelli, Bologna	Italy	320
Trinity Church, New York	United States	284
Westminster Cathedral, London	England	283
Church of Notre Dame, Paris	France	223
Bunker Hill Monument, Boston	United States	221
Leaning Tower of Pisa	Italy	179
Cathedral of Seville	Spain	150

Before the days of modern building construction men soared architecturally because they wanted to and not because they had to. They seldom spread out and went up too, however; therefore, the highest examples of building previous to the era of the modern office-building are confined to monuments and towers. —The Scrap Book.

METHODS OF CREOSOTE ANALYSIS.

THE growing scarcity of lumber, with the consequent high prices, is making it imperative that more attention be paid to preservative processes, whereby the time of service of timber may be lengthened. Coal-tar creosote is generally regarded as the most efficient of the wood preservatives. This product is very variable in composition, owing to differences in the coals used and in the methods employed in their distillation. Creosotes of different compositions are believed to have different values as wood preservatives, and an analysis of the oil used is, therefore, important.

No very large amount of study has been directed to perfecting the methods of creosote analysis, and the Forest Service, believing the matter vitally important to the progress of wood preservation, is now carrying on an investigation of these methods.

The most important part of a creosote analysis is the fractional distillation; since by this operation an approximate determination is made of the relative proportions of the most important substances in tar oil. There has been considerable divergence of opinion as to the best way of carrying out the fractionation of tar oils, some recommending a retort as a distilling vessel and certain temperatures for taking fractions, others recommending a distilling flask and a different set of temperatures.

Laboratory experiments carried on by the Service have shown that the difference in the weights of the fractions obtained when using different sorts of dis-

tilling vessels are not large, but that the composition of the fractions indicates a little better separation by the flask than by the retort. As regards the influence of the rate of distillation, variations of from one to three drops per second have but slight influence on the weights of the fractions, though the slower rate is more satisfactory.

It is commonly believed that the relative amounts of light oil, naphthalene, and anthracene oil are the most important factors determining the value of a creosote for wood preservation. A number of creosotes were very carefully fractioned, and determinations made of the amounts of naphthalene and solid anthracene oil distilling between various temperatures. The average of the results shows that at least 25 per cent of naphthalene was present in the distillate between 205 deg. and 250 deg. C., and that over 25 per cent of anthracene oil solids are present in the distillate above 300 deg. C. Work on the specific gravity and the index of refraction of the distillates between different temperatures is now being carried on.

The desirability of getting the criticisms and suggestions of users of creosote has led to the publication of a detailed account of the methods employed in the experiments and the results which have been obtained. Those who desire the publication should ask for Circular 80, Fractional Distillation of Coal-Tar Creosote. Request should be made to the Forester, Forest Service, Washington, D. C.

PATTERN-MAKING AND MOLDING OF CYLINDERS FOR TWO-CYCLE INTERNAL-COMBUSTION ENGINES.*

By E. F. LAKE.

THE two-cycle gas engine is divided into two classes, namely: the two-port and the three-port engines. The two-port engine was the first designed, and then, owing to the high speed required for marine and automobile use, the three-port engine was designed.

THE TWO-PORT ENGINE.

The two-port engine is called the valveless by some, as it does away with all valves in the engine proper, the gas being drawn by the piston on its upward stroke, through a check valve located in the intake pipe, into the crank case, which is made airtight. The piston on its downward stroke then closes this valve and slightly compresses the gas entrapped in the crank chamber, and when it reaches the lower part of its down stroke, opens a by-pass or intake port and the gas rushes into the compression chamber, driving out the burned gases through an exhaust port, which is opened a little before the intake port and remains open until after the intake port is closed by the piston on its upstroke, which compresses the gas again, and it is fired when the piston reaches the top.

THE THREE-PORT ENGINE.

The three-port engine does away with the check valve and uses a port in the wall of the cylinder at the top, either in the center of the top or in the side wall near the top. This port is usually opened and closed by a valve working automatically, the piston on its down stroke creating a vacuum which draws open the valve, allowing the fresh gas to flow in, and when the piston starts on its return or up stroke it releases the draw on the valve, and it closes with the aid of a small spring. The difference between the two styles is about the same as that between the suction inlet and mechanical inlet of the four-cycle gas engine.

ADVANTAGES AND APPLICATIONS OF THE TWO-CYCLE ENGINE.

The two-cycle engine is an eye-sore to the manufacturer of the four-cycle as it is much cheaper to make owing to the fact that it does away with the cam shaft, cams, cam-shaft gears, valve, valve rods, valve springs, etc.; therefore, the point that the two-cycle makers use of its not costing near as much for the up-keep of the engine, it having so many less parts to keep in repair, has a great deal of truth in it.

The two-cycle engine is used largely in marine work, being no doubt the best power at present for the small launch, and it is growing in popularity for automobile use.

HOW THE TWO-CYCLE ENGINE IS DESIGNED.

The designing of the two-cycle engine is not as easy as the designing of the four-cycle, as almost anyone with a knowledge of the designing of the steam engine and a little practice in proportioning can design a four-cycle gas engine, but with the two-cycle engine this knowledge and practice is often paid for by expensive experimenting, as the area of intake and exhaust ports and the time that each shall do its work—not only the exact period at which each should be opened and closed, but also the length of time each should remain open—must be worked out very accurately. This has been done by many manufacturers on the cut-and-try plan with the result that engine after engine has been built and then thrown on the scrap pile. In the early days of the gas engine this was the only method to pursue as there were very few rules to go by and many that were made had to be discarded and others substituted, but to-day there are many men who have accumulated the knowledge and experience which this cut-and-try method has brought out and they are called designers and engineers and are capable of constructing an engine on paper that will operate successfully when it is built. However, with this careful designing must go good mechanical work, as the best of designing can be spoiled by poor mechanical work.

* American Machinist.

TIMING PORT OPENING, AND FIXING UPON SIZE OF PORT.

The principal considerations on which a design is to be based are the action of the gases during the cycle, with the speed of the engine when running its slowest and developing full torque as a basis for the time of opening of the ports; and the highest speed which develops full torque as a basis for the width of the ports across the cylinder.

As an example it is not an uncommon thing for a three-port two-cycle engine designed to run at 600 revolutions per minute to hold its full torque at 1,100 or even 1,200 revolutions per minute.

COOLING THE MARINE ENGINE CYLINDER.

The two-cycle engine cylinder is always water-cooled for marine work, where it is used the most, as a fresh supply of water is always available and it can be water-cooled easier than air-cooled, and with less mechanical parts, and is almost always cooled by having a water jacket cast integral with the cylinder, through which a current of fresh water is kept circulating by a pump.

COOLING THE AUTOMOBILE ENGINE CYLINDER.

For automobile use, the two-cycle engine is nearly

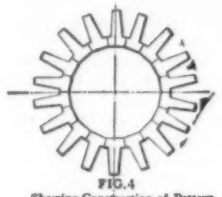


FIG. 4
Showing Construction of Pattern.

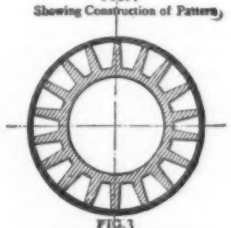


FIG. 3
Section on A A, Fig. 1.

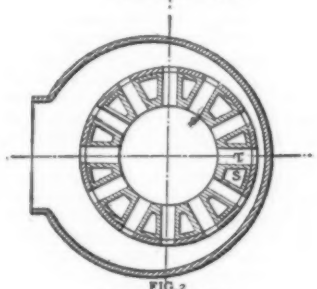
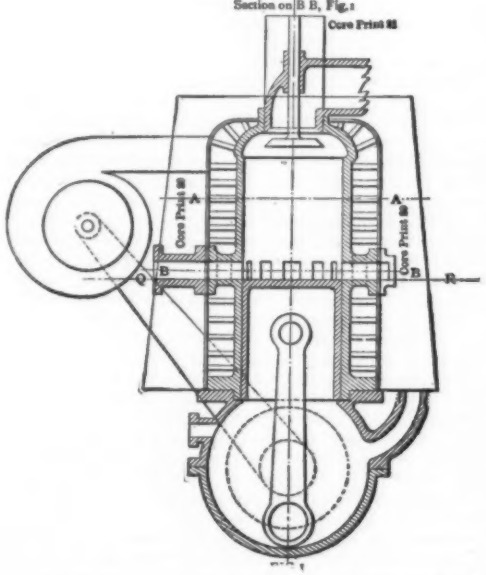


FIG. 2
Section on B B, Fig. 1



AIR-COOLED TWO-CYCLE ENGINE.

always water-cooled, as an explosion occurs every time the piston comes to the top of its stroke, so there is a great deal more heat to be carried away by the water than in the four-cycle, which has an explosion of gas only every other time the piston comes to the top or every second revolution of the crankshaft. Therefore, it is considered good designing, by some, to make the area of the water jacket larger in the two-cycle than in the four-cycle. Some, however, keep the area the same and increase the speed of the current of water passing through the water jacket, by speeding up the pump.

Many arguments are advanced to prove that the two-cycle engine is easier to cool than the four-cycle. One of them is that the incoming gas, being cool and coming in twice as often in the two-cycle as in the four-cycle, it must of necessity keep the cylinder cooler and leave less heat for the water to carry off, but while this is so at the point where it comes in, it is not so the minute it reaches the compression chamber where it explodes twice as often per given number of revolutions as in the four-cycle; or from there out through the exhaust port and passages which is of necessity delivered to the cylinder

This larger area of the water ... et or increase in the speed of the current of water necessitates the carrying of a larger water supply for automobile use when the two-cycle engine is used, which means a larger radiator for the same number of cylinders with the same bore and stroke. But this is more than offset by the fact that the impulses occurring twice as frequently per given number of revolutions in the two-cycle as in the four-cycle, fewer cylinders are necessary to hold the torque constant and for the same horse-power, per given number of revolutions. Thus a three-cylinder, two-cycle engine is the equal in horse-power of the four-cylinder, four-cycle, of the same bore and stroke, and some tests have shown a two-cylinder, two-cycle to rate as high in horse-power as a four-cylinder, four-cycle. So that while the volume of water carried would be greater, per cylinder of equal bore, stroke, and revolutions per minute, in the two-cycle than in the four-cycle, the volume of water carried would be less per horse-power, as the cylinders could be smaller or a less number used in the two than in the four-cycle plan, which will hold the same torque and deliver the same horse-power at the brake.

OTHER BENEFITS FROM THE TWO-CYCLE ENGINE ON AUTOMOBILES.

It is also possible to do away with the transmission change gears on the automobile by the use of the two-cycle engine, owing to its great flexibility and the use of the reversing engine for backing up. Many of the latter are made for marine use, the adaptation being accomplished by the use of a governor attachment and the moving of the ignition timer.

VARIOUS DESIGNS OF AIR-COOLED TWO-CYCLE ENGINES.

A number of different designs of air-cooled two-cycle engines are being brought out at present, which are more or less successful.

One that I have illustrated by Figs. 1, 2, 3, and 4 has a sheet-metal jacket between which and the cylinder wall, which is covered with pins cast integral with it, is forced a current of air by a fan or blower.

Another style of air-cooled, two-cycle engine is that having revolving cylinders, with flanges about ⅛ of an inch thick and from 1 inch to 1½ inches wide, covering the entire cylinder and cast integral with it. By the revolving of the cylinders they create their own current of air and are cooled by it.

THE OBJECTS AIMED AT BY THE DESIGNER.

Many different ways are adopted by the designers of the two-cycle engine cylinder in order to make the pattern-making, molding and machining easy; while others try to design the cylinders so as to reduce as much as possible the number of joints, which might cause a leak and spoil the effectiveness of the engine. As an illustration, some cast the cylinder and upper half of the crank case in one piece as shown in Figs. 5, 6, and 7; this makes much more work for the pattern-maker and molder and makes it more difficult for the machinist to bore out and grind the cylinder for the piston, but it does away with the finishing and packing at the joints which others use.

Some cast the cylinder in one piece, as shown in Figs. 8, 9, and 10, and then bolt it to the crank case. In this case where more than one cylinder is to be used in an engine, the crank case can be cast in one piece and two, three, or four cylinders, as the case may be, bolted to it. In this style the cylinder is easier to bore and grind and the crank case is more substantial, being in one piece, but the bottom of the cylinder and the top of the crank case must be machined and a tight packing put in, since in the two-cycle engine the crank-case compression is from four to eight pounds per square inch. Some make the top of the cylinder, that is above the line *A B*, Fig. 5, in one piece and the lower part of the cylinder and upper half of the crank case in one piece, that is below the line *A B*. This style requires machining and packing at the joint on the line *A B* which must be very tight, as it has to stand the explosion and expansion of the gases which drive the piston, but it makes it much easier to bore and grind the cylinder, as both ends are open and it makes it much easier to mold and make the pattern of, as the water-jacket core can be located in a print which goes around the entire pattern at the line *A B* and the cylinder core can also be located in a large print on the same line and the cylinder cast on end easily, which would result in fewer castings being lost.

Others cast the cylinder in two pieces, making one casting of the top above the line *C D*, Fig. 8, and another casting of that part of the cylinder below the line *C D*. This makes the patternmaking, molding, and machining of the cylinder still easier, as the pieces are smaller and easier to handle, and both ends of the cylinder are open, making it easy to bore, the cores easy to set, and the core-boxes and patterns easy for the patternmaker to make, it is also less costly to replace a cylinder when one wears out, but it makes a joint at the compression chamber on the line *C D*, which must be machined very accurately and two packing rings of an equal thickness inserted, one between the compression chamber *E* and water jacket *F*, Fig. 8, to prevent the gas from going out when it explodes with a maximum pressure of from 250 to 300 pounds per square inch, or the water from coming into the cylinder and disturbing the action of the gases and piston. The other packing ring is between the water jacket *F* and the outside of the cylinder. Another joint is also necessary between the cylinder and the

crank case, but this is not as important as the one on the line *C D*, Fig. 8, as the pressure is nowhere near as [illegible]. These joints also add to the weight of an engine [illegible] losses are added to the casting for the bolts and [illegible] studs or bolts; and nuts are added which might become a source of trouble from working loose. Each style, therefore, presents good and bad qualities, and it is up to the buyer to select the one which suits his ideas or his pocketbook the best.

THE ELMORE CYLINDER.

Figs. 8, 9, and 10 represent the type of two-port, two-cycle engine for automobile use, used by the Elmore Manufacturing Company, of Clyde, Ohio, which has given much satisfaction. This style can be molded by being parted on the center line *G H*, Fig. 8, and the lower half of the water-jacket core placed in the mold and located by core prints Nos. 1 and 2, Fig. 9; besides this it would be necessary to support the core by

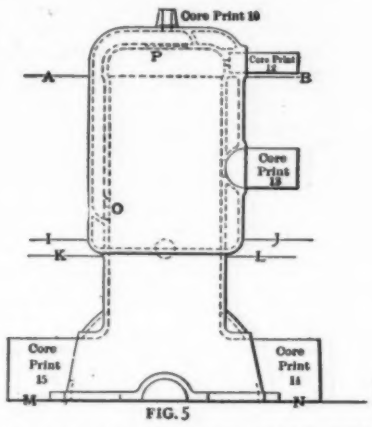


FIG. 5

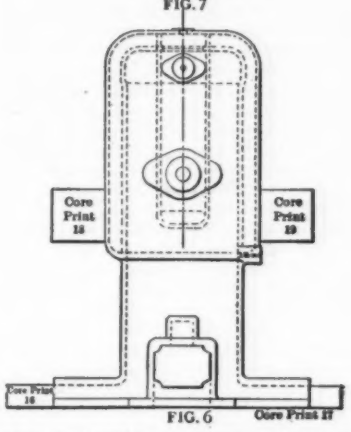


FIG. 6

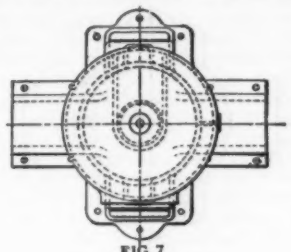


FIG. 7

WATER-COOLED TWO-CYCLE ENGINE CYLINDER, "THREE-PORT" TYPE, CAST INTEGRAL WITH UPPER HALF OF CRANK-CASE

chaplets, which is poor practice, where they can be avoided, owing to the liability to cause a leakage around them as they do not always fuse with the iron when poured. The use of chaplets could be overcome by cutting holes for the core through the outside cylinder wall at 4 and 5, Fig. 8, and locating it with core prints at this point. These holes could afterward be plugged or plates fastened over them with screws. The center or cylinder core could then be placed in position by locating in core prints 3 and 6, Fig. 9. At core print 3 it would be advisable to use a perforated iron pipe running entirely through the core, owing to the core print being so small a support for such a large core; this pipe could also serve as a vent to the core. Then by locating in the mold an iron plate, with a half round in it to fit the pipe, the core would remain in position, and not settle, and cause thin metal on the lower sides of the casting and thick metal on top. The core that forms the exhaust passage could then be located in core print 7. The core that forms the passage for the gas to enter the crank case could be located in core print 8, and the core that forms the by-pass for the gas from the crank case to the compression chamber could be located in core print 9. Core prints 7, 8, and 9 should be long enough to balance the cores so they would not tip in the mold. Then by placing the top half of the water-jacket core on and pasting it to the lower half, the mold is ready to close and pour the iron in.

THE "THREE-PORT" CYLINDER.

Figs. 5, 6, and 7 illustrate the three-port, two-cycle type; so far as the cylinder is concerned there is very little difference, and this one can be molded in a similar manner to the one just described, or both could be molded on end. I will describe the molding of this one on end, which could be applied to the one described above by a few changes in details.

In order to mold this on end, it would have to be done in a three-part flask. This could be done by parting the pattern on the line *K L*, Fig. 5; the mold would have to be parted on the lines *I J* and *M N*. After the pattern was drawn from the mold, the cores which form the opening for the spark plug at core print 12, and the opening for the exhaust at core print 13, could be placed in their respective places, and by making them shorter than the core print, they could be pushed back in the mold until after the water jacket and cylinder cores were set, and then from the outside of the mold they could be pushed in until they touched the cylinder or center core. The water-jacket core could then be lowered in and located by core prints 18 and 19, Fig. 6. The center core could then be lowered in and located at the bottom by core print 10 and at the top by core prints 14 and 15, Fig. 5, and core prints 16 and 17, Fig. 6. These prints would carry all the weight of the core, so that core print 10 would merely locate it at the bottom and prevent the core from washing to one side or the other. Integral with this core would have to be made the by-pass core, which connects with it at *O* and *P*, Fig. 5.

MAKING THE CYLINDER FOR AN AIR-COOLED, TWO-CYCLE ENGINE.

Fig. 1 is an assembly view of an air-cooled, two-cycle gas engine and Figs. 2 and 3 are sectional views of the same. There are not many air-cooled, two-cycle gas engines on the market at present, and none that have come into prominence as they are still in the embryo state, but there are many experimenting with them and some practical ones may be brought out before long.

As this article is only dealing with the cylinders, I will confine myself to that alone and not describe any of the other pieces shown. About the only way that this can be molded successfully is to inclose the whole pattern in a core box as shown by core print 20, Fig. 1, then it will be necessary to make this outside core in two parts, splitting it on the line *Q R*, in order to get in the core the air passages at *S*, Fig. 2. These passages allow the air to circulate past the exhaust chamber which is located at the line *B B*, Fig. 1, also to get the exhaust passages which are located on the same line and are shown by *T*, Fig. 2. These exhaust passages are around the entire circumference of the cylinder and are carried out through the air jacket by a flange-like arrangement over which is fitted a ring that has an opening at one side to carry away the exhaust. This ring also serves to hold the sheet-metal water jacket in position at this point. The outer wall of the cylinder being covered with pins cast integral with it, it is necessary to build the center of the pattern barrel shape and then pin to this barrel loose staves as shown in Fig. 4, each stave to take care of a row of the cooling pins which are cast on the cylinder; then a ring can be built on the top of the core box which makes the outside core above the line *Q R*, Fig. 1, with the air passages *S* and the exhaust passages *T*, Fig. 2, in it. After the core is rammed up, this ring is taken off, then the center or barrel of the pattern is drawn out of the core box and the staves with the cooling pins on are drawn into the center of the core and out, leaving the core ready to dump out of the box. The same operation is gone through with in making the outside core below the line *Q R*, Fig. 1, except that in this ring there is only a part of the air passages *S* to be taken care of, the exhaust passages all being made in the other core box. In molding it after the plain round pattern, built to the outer line of core print 20, has been drawn from the sand, the outside core above the line *Q R*, Fig. 1, is lowered into the mold, then the center core is lowered in and located by core print 21 at the bottom and another core print at the top for the cope to lower down over, then the outer core below the line *Q R* is placed in position and pasted to the other part as shown above the line *Q R*, whereupon the mold is ready to close and pour.

The molding of this in dry core sand will insure the iron flowing more freely and give a better casting than if it were molded in green molding sand and it would give even better results if the mold were placed in the core oven and warmed just before the iron was poured in.

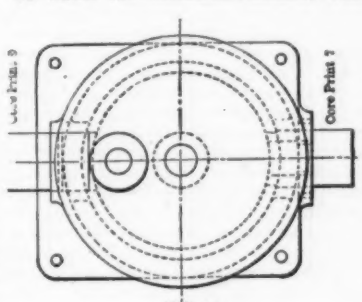


FIG. 10

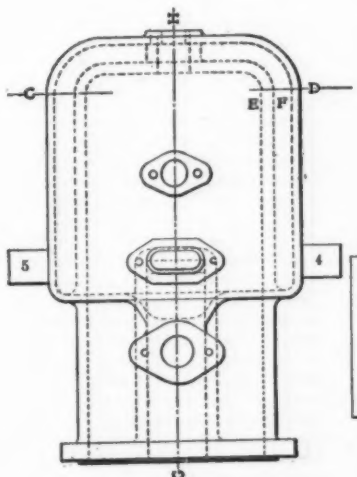


FIG. 8

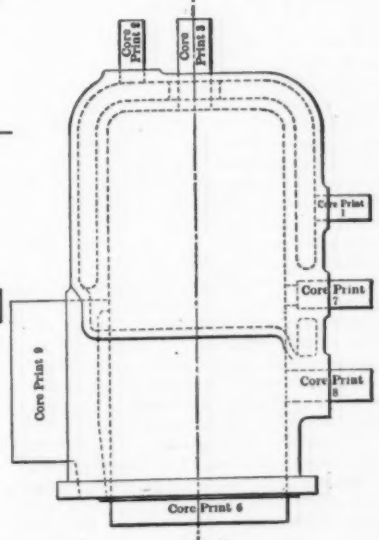


FIG. 9

WATER-COOLED TWO-CYCLE AUTOMOBILE ENGINE CYLINDER "TWO-PORT" TYPE, CAST SEPARATE FROM CRANK-CASE.

METHODS OF ASTRONOMICAL MEASUREMENT.*

WE may find the place of the sun among the stars by observation of the difference of the times of transit of the two bodies. If we do this again at the end of one year, we have a result for the length of the year which will be in error by the whole amount of the errors of observation. But by comparing observations one hundred years apart, the error of observation is divided by one hundred. Similarly ancient eclipses observed thousands of years ago, when they can be properly identified, are referred to for the purpose of correcting astronomical constants.

Thus while the absolute facts of the solar system as to distances and masses are subject to the uncertainties attendant upon determining those of the earth, and transferring them to such distant bodies, their relative values are very accurately known.

Outside the bounds of the solar system our knowledge is by no means so complete. Sidereal astronomy consists at the present time largely in the accumulation of facts with regard to isolated stars or systems, investigations of the orbits of double stars, parallaxes of stars and the like.

Toward the solution of the problem of the direction and velocity of the sun's movement in space, considerable progress has been made.

This problem has been attacked, as by Herschel, by measurement of the proper motions of stars. The directions in which we see the stars have not relatively changed during historical times sufficiently to be noticed by the eye, or by rough instruments. Modern observations have shown, however, that the stars are in motion, and their angular movements have been the subject of continued observation.

We, of course, see only that part of the motion which is at right angles to the line of sight, and w know only its angular value; not its absolute amount, for we do not know the distance, except in a few instances.

If the sun is moving in space, some part of this proper motion must be due to the sun's motion. If the sun is moving toward a particular point of the sky, the tendency will be for the stars to appear to move away from that point, and to move toward the opposite point of the sky.

As this effect is mixed up with the real motions of the stars themselves, these are eliminated by what may be called the statistical method, which proceeds on the assumption, that if a great number of stars are taken, there will be as many real movements in one direction as in another, and, in the long run, of equal amounts. Therefore resolving the observed proper

* Abstracted from the Inaugural Address of W. F. King as President of the Royal Astronomical Society of Canada.

motions into directions at right angles to one another, and averaging the results, the real motions are eliminated (to a large extent at least) and the residual effect represents the sun's movement in space.

Lately, this method has been superseded by the spectroscopic method, in which the velocities in the line of sight are measured. This has the advantage over the other method, that we are dealing with absolute lengths in miles, and have not to depend upon the assumption that velocities of stars at different distances will balance one another when expressed in angular value. Moreover the work goes on more rapidly; each observation is complete in itself, while the determination of proper motions to an equal degree of accuracy, requires observations to be taken many years apart.

As before, the statistical method is applied to the measurements of velocity. The part of the velocity which is proper to the star itself is assumed to be eliminated by combining a very large number of stars, and that part which is due to the sun's motion alone remains.

Other systematic investigations might be mentioned, such as the systematic mapping of the stars by photography undertaken by co-operation of many observatories, photometric determinations of the brightness of the stars, etc.

AGRICULTURAL PROBLEMS.

WE have really not endeavored, as a people, to solve our technical agricultural problems until within the present generation. We have escaped the problems by moving on to the West. Thereby we have fallen into the habit of treating symptoms rather than causes, as the policeman does when he orders the offender to "move on," and leaves the real difficulty for some one else to solve. Even yet, farmers are moving on to find land that is not depleted and regions free of blights and of pests. The real development of agriculture lies in developing the old areas, not in discovering new ones. When virgin land can no longer be had, scientific agriculture will be born. An isolated island develops something like a perfected agriculture, as one may see in Bermuda or Jersey. The earth is an island; in time it will be developed.

LIGHT AND ILLUMINATION.*

By CHARLES P. STEINMETZ.

COMPARED with other branches of engineering, as the transformation of electrical power into mechanical power in the electric motor, or the transformation of chemical into mechanical energy in the steam engine, we are at a disadvantage when dealing with light and illumination, because we have not to do strictly with a problem of physics, but are on the borderland between applied physics, that is, engineering, and physiology. Light is not a physical quantity, but is the physiological effect exerted on the human eye by certain radiations. There are different forms of energy, all convertible into each other, as magnetic energy, electric energy, heat energy, mechanical momentum, radiant energy, etc. The latter, radiant energy, is a vibratory motion of a hypothetical medium, the ether, which vibration is transmitted or propagated at a velocity of something like 186,000 miles per second. It is a transverse vibration, differing from the vibratory energy of sound in this respect, that the sound waves are longitudinal, that is, the vibration is in the direction of the beam, while the vibration of radiation is transverse. Radiant energy can be derived from other forms of energy, for instance, from heat energy, by raising a body to a high temperature. Then the heat energy is converted into radiation and issues from the heated body, as, for instance, an incandescent lamp filament, as a group of radiations of different wave lengths, i.e., different frequencies. All frequencies appear from very low frequencies, that is, only a few millions of cycles per second, up to many times higher frequencies. If desired, much lower frequencies in electromagnetic waves may be produced, such as the radiations sent out by an oscillating or an alternating current; but the radiations which are given by heated bodies are all of extremely high frequency as compared with the customary frequencies of electric currents. At the same time they cover a very wide range of frequencies, many octaves, and from all this group of radiations, of all frequencies, somewhat less than one octave can be perceived by the human eye as light. Light, therefore, is the physiological effect exerted upon the human eye by radiations within a certain narrow range of frequency. Frequencies lower than these, as well as those higher, are invisible. Those frequencies lower than the visible ones are called radiant heat. The higher ones are known as chemical rays. These terms, however, are misleading, and there is no distinction in character between radiations of different frequency. There are no heat rays differing from light rays or chemical rays. Any form of energy when destroyed gives rise to an exactly equivalent amount of some other form of energy. If, therefore, radiant energy is destroyed by intercepting the beam by interposing an opaque body in its path, then the energy of radiation is converted into some other form of energy, usually into heat. Any radiation when absorbed produces heat, and the amount of heat produced merely represents the amount of energy which was contained in the radiation. If the radiation contains a very large amount of energy, the heat developed by intercepting it may be sufficient to be felt by putting the hand in the beam. If the amount of energy is less, it may not be possible to feel it, though with a sensitive instrument, such as a bolometer, it may be possible to measure the heat. All radiations, therefore, are convertible into heat, the visible light waves as well as the invisible ultra-violet rays, and the usually more powerful long infra-red rays; but none of the radiations can be called heat, any more than the mechanical momentum of a flywheel is heat, because when destroyed, it produces heat.

Considering the infinite range of radiation issuing from heated bodies, it is found those rays which are of frequency lower than the visible rays will be felt as heat, because they contain a large amount of energy. The rays which are visible represent very little energy, and therefore they do not give as much heat. For instance, in the case of a hot steam boiler, although it sends out no light, the radiation from it can be felt by the heat which it produces when intercepted by the hand held near it. The radiation which issues as green light from the mercury lamp cannot be felt as heat merely because the energy of this radiation is less than the amount of energy in the radiation from a hot boiler; but, while it is less, it happens to be of that frequency which affects the eye and is visible. It results from this that when one speaks of cold light, it is not meant that it is different from hot light; from the light, for instance, given by a hot coal fire, where the radiation is felt as heat; it merely means that what is usually called cold light, as, for instance, the light of the firefly, is radiation containing to a very large extent rays of the visible frequencies and not much energy outside of the visible range; i. e., containing very little total energy, so that the energy when converted into heat, cannot be felt easily, but requires more delicate methods of determination. On the other hand, a very inefficient light, as a coal fire, for instance, which gives most of its energy as invisible radiations of low frequency, and very little as visible, can be felt by the heat produced by the interception of the rays, which are mainly the energetic low-frequency rays. As stated, then, there is no essential difference between so-called heat waves and light waves, but any radiation can be converted into other forms of energy, the so-called chemical rays of ultra-violet light, the X-ray, as well as infra-red and the visible rays, and when converted into heat can be detected as such. Now, it just happens that most of the available means of producing radiant energy give high intensities of radiation for low frequencies only, the invisible infra-red rays, but it is not now possible to produce anywhere near the same intensity of radiation as higher frequencies.

So, also, when speaking of ultra-violet, or high-frequency radiations, such as chemical rays, that does not mean they have a distinctive character in producing chemical action. Any form of energy can be converted, if one knows how, into chemical energy; the long ultra-red waves just as well as the short ultra-violet waves. It just happens that those chemical compounds which are easily split up by radiant energy, such as silver salts or salts of gold and platinum, are especially affected by the ultra-violet and violet rays. For this reason, the chemical action of these rays is more noticeable than the other rays. There may, however, be some feature in the constitution of matter, which accounts for the high chemical action of the ultra-violet and violet rays. It is obvious if the radiations are intercepted and destroyed and their energy converted into other forms of energy, if the energy is only high enough, a high temperature results, and so high chemical action is produced by the mere effect of temperature. But there may be a chemical effect by what probably is some kind of resonance phenomenon. The particles of a body, atoms, or molecules, must have some rate of vibration of their own. If, then, a ray of radiation impinges upon them which is of a frequency of the same magnitude as the inherent rate of vibration of the atom, by resonance this vibration of the atom must rapidly increase in intensity until the atom breaks away from the others, or the molecule breaks up; that is, the chemical combination is split up. The inherent frequency of oscillation of the atom seems to be about of the same magnitude as the visible radiations, or rather a little higher; that is, if the atoms are left to vibrate freely, as under the influence of an electric current in the arc, then radiations of the frequency inherent to the atom are given off. The general tendency is toward the violet or short wave end of the spectrum. If one assumes that the mass of the silver atom is such as to give a rate of vibration in the range of the violet and ultra-violet, it is easy to understand that a radiation of this frequency will split up the silver salt by increasing the vibration of the atom through resonance, and that shorter or longer waves will have no effect, or one much less. So it may be a mere incident that those chemical compounds on which the chemical action of radiation is marked just happen to be sensitive to the violet end of the spectrum. It is, indeed, a fact that other chemical changes are brought about by radiant energy, as the formation of ozone from oxygen, which is the splitting up of the oxygen molecule and the forming of the ozone molecule from the atoms and does not take place in the violet or ultra-violet, but requires frequencies much higher, about the highest frequencies which the mercury arc gives at low temperature. Possibly, since the oxygen atom is so much lighter than the silver atom, its frequency of vibration is much higher; which means that resonance effects and destruction of the molecules take place only with a much shorter wave length of radiation.

Inversely, it seems that those frequencies which are chemically active in organic life, which give the energy absorbed from radiation by plants and bring about the chemical activity utilized in building up the growth of vegetation, are at the red end of the spectrum, not at the violet end. It appears that the red and infra-red rays produce growth of plants and the chemical activity called life, while the violet and ultra-violet rays kill. Even this can be understood if the chemical activity is considered as a resonance phenomenon, because the metabolism of protoplasm which is called life is based on the existence of unstable structures of carbon compounds. Here it is not atoms which are combining with each other, but groups, chain and ring formations, which are of larger mass and therefore have a lower rate of vibration and so should be expected to respond to lower frequencies or to red light, as indeed seems to be the case. The violet and ultra-violet light do not split up the organic matter into groups, which recombine to form complex bodies, and so represent the changes called life; but due to their higher frequencies, resonance occurs with the atoms, and the organic compound splits up into atoms and so disintegrates, which means death.

Thus it can be understood that the chemical activity of different radiations may be different, the chemical activity of long rays give life to vegetation and the short waves death; one splits the compounds up into carbon groups and the other carries destruction down to the atom.

Thus, the popular distinction between heat waves, chemical waves, light waves, is not a physical distinction, as all are radiant energy of the same character and differ merely in wave length. The visible range is somewhat less than one octave rather at the upper end, at the higher frequencies which are difficult to produce.

The problem of investigating and dealing with light is difficult for the engineer, because it is not a physical quantity which can be measured accurately, as in the case of power or velocity, but it is a physiological effect. The total energy of radiation from a heated body may, indeed, be measured very accurately, but the total energy of radiation is not light; only a very small part of it is visible. It is possible to go further and split up the total radiation issuing from a hot body, as from an incandescent lamp filament, into its different wave lengths of different frequencies, by resolving it into a spectrum by means of a prism, and then to collect all of the radiation within the visible range by a lens or other means and measure the energy of these radiations. Or, still simpler, some medium, such as glass or water, which absorbs the invisible long rays and invisible short rays, and which transmits all, or nearly all, of the visible rays, may be interposed in the beam of radiation. In this manner the energy of the visible radiations may easily be measured and compared with the total energy radiated. That would give a physical measure of the efficiency of the process of producing visible radiation, but it would not be a measure of the efficiency of producing light, since, unfortunately, the different wave lengths of the visible radiation have very different physiological effects. A given amount of energy as visible radiation, giving the effect of green light, represents an entirely different amount of light and causes a much greater physiological effect than the same amount of energy in rays of the wave lengths which give the impression of red light.

It follows from this that the physiological effect, or light equivalent of mechanical energy within the visible range, is a function of the wave length and varies with the color. That really is obvious, because the energy radiated at low frequencies represents no light whatever and has no physiological equivalent; it is invisible. Coming to the visible range, there is a physiological effect, that is, light. Therefore, in passing from the invisible into the visible range the physiological equivalent must pass from zero into a finite value and must necessarily pass continuously. At the extreme end of the visible range, the light equivalent of energy must be extremely low, and the further one goes into the visible range, the greater it is. The maximum is reached in the middle of the visible range, in the green and yellow. Then it decreases down to zero at the violet end of the visible rays; beyond that, at still higher frequencies, the physiological equivalent of energy is zero also. Or, inversely, the mechanical equivalent of light is a minimum in the middle of the visible range, where one candle-power of light represents the lowest amount of energy, and increases toward the ends of the spectrum of the visible range, reaching infinity at the ends. In other words, the efficiency of light production is a function of the wave length, that is, of the color, and is at its maximum in the middle of the spectrum, where the same amount of power, measured in watts, gives the largest amount of light measured in candle-power.

Unfortunately, the physiological equivalent of power, or the physiological effect of light, varies not only with the wave length, but also with the absolute intensity. If it be required to compare red, yellow, and green lights, or any lights of different colors, great difficulties are met. Suppose one candle-power is wanted in light, as red, yellow, or green. The different colors cannot be compared directly, since there is no physical measure of light. Lights are compared with a standard lamp, which has a certain color, usually a yellowish white. Lights of the same color can be compared exactly. If the color is not much different, an approximate comparison may still be made; but with widely different colors not even an approximate comparison can be made. One cannot say when the two sides of the photometer screen, one illuminated by green light, the other by red light, are equal in intensity. Thus, there can be no direct comparison of different colored lights. It is necessary to go one step farther and consider that light is used for illumination, is used to see by, and this gives a fair method of comparison: let it

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be observed at what distances from the two lights, red and green, there is the same ease in reading the same print; or, to measure more exactly, get the maximum distance at which a certain size of print can just be read by each light. At these distances the two illuminations are the same, and so the two lights have intensities inversely proportional to the squares of the distances. In this manner lights of different color can be compared.

Necessarily, the comparison has not the accuracy of a photometrical comparison. This cannot be expected, since physical quantities are not compared, but only physiological effects on the eye, and different observers may have different personal constants. The eye of the one may be more sensitive to green, and the eye of the other to red, and therefore the comparisons may be different. However, these individual differences are not great, and different observers, even with widely different colors of light, do not give results differing much from each other; so that a comparison of intensities of different colored lights, and thereby a measurement of the intensity of different colored lights in candle-power, is feasible, by some such method.

It is found, however, with a green light and a red light, which at a certain distance appear equally brilliant to the eye, when approached the red light appears much brighter than the green, and receded from the green light appears brighter, and at greater distances the green light may still be fairly bright when the red light is almost invisible. That is, the relative physiological effect of different wave lengths varies, not only with the wave lengths, but also with the absolute intensity of illumination, and while throughout the whole range the sensitivity of the eye for green light is much greater than for red light, the difference is far greater for low than for high illuminations. That is, the ratio of sensitivity for green compared with that for red is greater for faint illuminations than for intense illuminations. If it be desired to express lights of different colors in candle-power, it seems necessary also to give the distance, or the intensity of illumination at which the observations were made. In other words, the light from the middle and the short wave end of the spectrum gives a better and more efficient illumination when the total intensity of illumination is low than the long or low frequency rays of red, orange, and yellow, but the latter colors give a much more brilliant effect at high intensities than the same amount of light of shorter wave length.

This is of importance for the illuminating engineer, because when it is desired to get high intensity effects, as in decorative lighting or in advertising, better results are given by the low frequency end of the spectrum, by orange and yellow light, whereas when a low intensity of illumination is satisfactory, as in street lighting, better results are given by the short wave end or the middle of the spectrum, by the greenish-yellow of the Welsbach gas lamp and the bluish green of the mercury lamp. Therefore the white light of the carbon arc gives better results in street lighting than the yellow of the incandescent lamp, even at equal intensity of illumination. These features have been of small importance until recent years, since the available sources of light were all approximately of the same color, varying from orange-yellow, to yellow and yellow-white, to white; from the orange-yellow color of the gas lamp, kerosene lamp, and tallow candle to the yellow incandescent lamp, the yellowish-white arc, the yellowish-white sunlight, to the white diffused daylight. This was a fairly limited range. It is only in the last few years that illuminants of high efficiency have been brought out which give marked and decided color differences and are available in units of suitable size and of high efficiency; such, for example, are the greenish-yellow Welsbach gas lamp, the bluish-green mercury lamp, and the orange-yellow flaming arc. Hence, these questions of color are increasing in importance.

II.

Until a few years ago, until the development of the Welsbach gas mantle, practically all methods of producing light were based on incandescence. That is, by impressing energy on a solid body, either the chemical energy of combustion, or electric energy in the incandescent or carbon arc lamp, the temperature is raised to such a high value that among the total radiation issuing from the heated body a certain very small percentage appears within the fraction of an octave of visible light. With increasing temperature of the radiating body, the average wave length of radiation decreases; that is, the average frequency of radiation increases, and so approaches nearer to the visible range, although even at the very highest temperature which can be produced the average wave length of radiation is very far below the visible. This means that the higher the temperature reached by an incandescent body, the higher is the average frequency of radiation, and so a larger percentage of the total energy of radiation is within the visible range and is light. Thus, the problem of efficient light production by incandescence is the problem of reaching as high a temperature as possible in the luminous body. In the gas flame and the kerosene lamp, this temperature is the temperature of combustion, and is rather limited. In the incandescent lamp it is limited also. In the latter case the temperature which can be reached is limited by self-destruction of the incandescent body.

Probably the highest temperature which can be reached is the boiling point of carbon; it is reached in the crater of the carbon arc lamp, and therefore the carbon arc gives the most efficient incandescent light. It is incandescent light because it comes from the incandescent crater, and the arc flame or the vapor conductor does not appreciably contribute to the amount of light issuing from the lamp. Very much lower, necessarily, is the temperature of the carbon filament of the incandescent lamp.

The problem is to find materials which can stand very high temperatures, to increase the temperature of the gas flame as well as of the incandescent filament. The temperature of the gas flame has been increased by using a gas of higher chemical energy, as acetylene. The acetylene flame is white; the ordinary gas flame is yellow. The temperature of the carbon filament has been increased by replacing the carbon with some more refractory material, such as tantalum, osmium, tungsten, etc., and thus a higher efficiency is obtained. The temperature of the gas flame may be increased by increasing the rapidity of combustion. The temperature of the carbon filament in the incandescent lamp may be increased by increasing the energy input, but if the temperature of the carbon filament be increased, it is more rapidly destroyed. The temperature of the gas flame has been increased by more rapid combustion to a certain extent by having the gas issuing, not from a round hole, but from a flat slit, so as to give a larger surface to the flame. By going still further and mixing the gas with air, a still higher temperature and a more rapid combustion are obtained, but the incandescent body is destroyed, because the incandescence of the gas flame is the light given by carbon or heavy hydrocarbon particles floating in the gases of combustion. The efficiency of the gas flame may be increased by mixing the gas with air, as in the Bunsen flame, but it is then necessary to insert a luminous body of some other material in place of the carbon produced by the gas by its dissociation. This may be done by a skeleton of platinum wire. In no case, however, can very high efficiencies by incandescence be reached, because of the temperature limit.

However, the efficiency of light production might be increased if an incandescent body be found which does not radiate in the same manner as the carbon filament or the so-called black body, but which gives an abnormally low radiation in the low-frequency range, or an abnormally high radiation in the high-frequency or visible range. Such a body may be said to give selective radiation, because the distribution of energy among the different frequencies of radiation in the spectrum is not the same as it would be with an ordinary black body at the same temperature. If a body be found which gives an abnormally low radiation in the visible range, or abnormally high radiation in the invisible range, this body would be an abnormally inefficient light producer. Inversely, if a body gives abnormally high radiation of short wave lengths in the visible range, or abnormally low radiation of long waves of low frequency, this would be an abnormally efficient incandescent body. Such bodies exist and the enormous progress in gas lighting made by the introduction of the Welsbach mantle is based on such selective radiation; that is, the oxides do not radiate the same range and intensity of waves as a black body, the incandescent carbon, but give an abnormally large amount of visible rays compared with invisible rays; that is to say, they give a larger percentage of high-frequency light rays compared with the low-frequency invisible rays. Possibly, and even probably, some of the highly efficient metal filaments, like the tungsten filament, also owe their high efficiency of one watt per candle-power to selective radiation.

When discussing selective radiation, it is necessary first to come to an agreement on what is understood by selective radiation. The question whether an illuminant owes its high efficiency to selective radiation, depends largely on the definition of the term "selective radiation." This is a case similar to the much-discussed problem of the "counter-electromotive force of the electric arc." Whether the electric arc has a counter-electromotive force or not entirely depends on the definition of counter-electromotive force. In the same way, the decision on the question of selective radiation depends on what is defined as selective radiation. If selective radiation be defined as any radiation in which the intensity of radiation is distributed through the total spectrum differently from that of the theoretical black body, then the Welsbach mantle shows selective radiation. If, however, selective radiation be defined as the radiation of a body which gives spectrum lines, or bands, or absorption lines and bands, that is, sharply defined narrow ranges in the spectrum, of abnormally high or abnormally low intensity, then the Welsbach mantle shows no selective radiation. So all discussions and statements on selective radiation have rather little meaning if the writer does not give his definition of selective radiation. In the following I define as selective any radiation which differs in the distribution of its intensity from the radiation of the theoretical black body.

In an incandescent lamp filament a definite pitch, or definite frequency of vibration, is not given, but there is an infinite number of different waves. The reason is, perhaps, that in a solid or liquid body the vibrating particles are so close together as to interfere with each other. If a body could be set in vibration, in which the vibrating particles, atoms or molecules, are so far apart as not to interfere with each other, as, for instance, in a gas at low pressure, then they would execute their own periods of vibration, and the light from such a body would not be a radiation of all wave lengths, but a radiation of only a few definite wave lengths, or a line spectrum. Thus, incandescent or luminous sodium vapor gives only one kind of light, a yellow spectrum line, and in addition thereto a number of infra-red and ultra-violet rays.

Since the spectrum light is based on the non-interference of the vibrating particles, it is easy to understand that when the atoms or molecules are brought closely together, as at atmospheric pressure, interference may begin, and the lines of the spectrum become confused and blur into bands. Thus the mercury arc spectrum, which is at low vapor pressure, consists of a small number of definite sharply defined lines. In the calcium spectrum of the flame carbon arc there is a large number of lines blurring into each other and forming an almost continuous spectrum; so it is also in the white spectrum of the magnetite-titanium arc.

When a gas or vapor is set into vibration, it vibrates at its own frequency, independent of the temperature, and it is merely a question of the character of the material whether a very large percentage of the total energy of radiation happens to be within the visible range or outside the visible range. Temperature does not come in as a factor, because the frequency of radiation is no longer a function of the temperature, but is independent of it; sodium vapor gives the same frequency of radiation, the same yellow line when the sodium vapor is at low temperature or at high temperature. Some spectrum lines may increase in intensity with an increase of temperature faster than others, and the color of light may change with the temperature, may change from yellow to white or blue, or from green toward white or red, as the mercury light does with increasing temperature, but that is merely a characteristic feature of that particular body, and not a general temperature effect. The possibility therefore exists of finding materials which, when energized as vapor or gas, give a spectrum with a large amount of energy in the visible range, thus giving an efficiency of light production far in excess of that available by incandescence.

So far the only materials which give these characteristics are mercury, calcium, and titanium. These three metals give spectra which contain such a large percentage of the total radiation in the visible range that the amount of light measured physiologically in candle-power is far in excess of that which possibly could be produced by incandescence, even with the assistance of selective radiation. Their industrial applications are represented by the mercury arc, the yellow flame carbon, and the white magnetite-titanium arc lamps, and these have a higher efficiency than any incandescent lamp.

Considering these three illuminants only, there is a considerable color scale; from the orange-yellow of the flame carbon, which is about the longest wave length which could be used, to yellow and yellow-white in the acetylene flame and the tungsten filament. Then there is the greenish-yellow of the Welsbach mantle, due to selective radiation. Next are the bluish-green in the mercury arc, the yellowish-white of the carbon arc, and the clear white of the titanium arc. Each of these can be modified. The titanium arc may be given all colors from yellow-white to bluish-white by the addition of materials which give either yellowish or bluish spectra. The yellow calcium arc may be modified from the orange-yellow of calcium fluoride down to the yellowish-white of calcium borates. It is possible to get nearly any color, with the exception, perhaps, of a clear blue or violet; no means have been found to get approximately the same efficiency in these colors of very short wave length.

This feature makes the effect of color discussed before—the variation of the physiological effect with the brilliancy of illumination—of more importance now than years ago when the only method of producing light of any color was by the absorption of all other colors.

(To be continued.)

Perception of Sound Direction.—In an interesting paper on this subject Lord Rayleigh finds that "when a sound of low pitch reaches the two ears with approximately equal intensities but with a phase difference of one quarter of a period, we are able so easily to distinguish at what ear the phase is in advance, must have far reaching consequences in the theory of audition." It seems no longer possible to hold that the vibratory character of sound terminates at the outer ends of the nerves along which the communication with the brain is established. On the contrary, the processes in the nerve must themselves be vibratory, not, of course, in the gross mechanical sense, but with preservation of the period and retaining the characteristic of phase—a view advocated by Rutherford, in opposition to Helmholtz, as long ago as 1886. And when we admit that phase differences at the two ears of tones in unison are easily recognized, we may be inclined to go further and find less difficulty in supposing that phase relations between a tone and its harmonics, presented to the same ear, are also recognizable. In observing fog signals at sea it is, of course, of great importance to be able to estimate the bearing. If a sound is of sufficiently long duration (5 or 6 seconds), it is best by turning the body or head to bring it apparently to the right and to the left, and to settle down into the position facing it where no lateral effect remains. If, as for most fog signals, the duration be decidedly less than this, it may be preferable to keep still; but we are then liable to serious errors, should the signal happen to come from nearly in front or nearly behind; a judgment that the signal is to the right or left may usually be trusted, but a judgment that it comes from in front or behind is emphatically to be distrusted. If, for example, the sound seems to come from a position 45 deg. in front of full right, we must be prepared for the possibility that it is situated 45 deg. behind full right. A combination of three or four observers facing different ways offers advantages; a comparison of their judgments, attending only to what they think as

to right and left and disregarding impressions as to front and back, should lead to a safe and fairly close estimate of direction.—Phil. Mag.

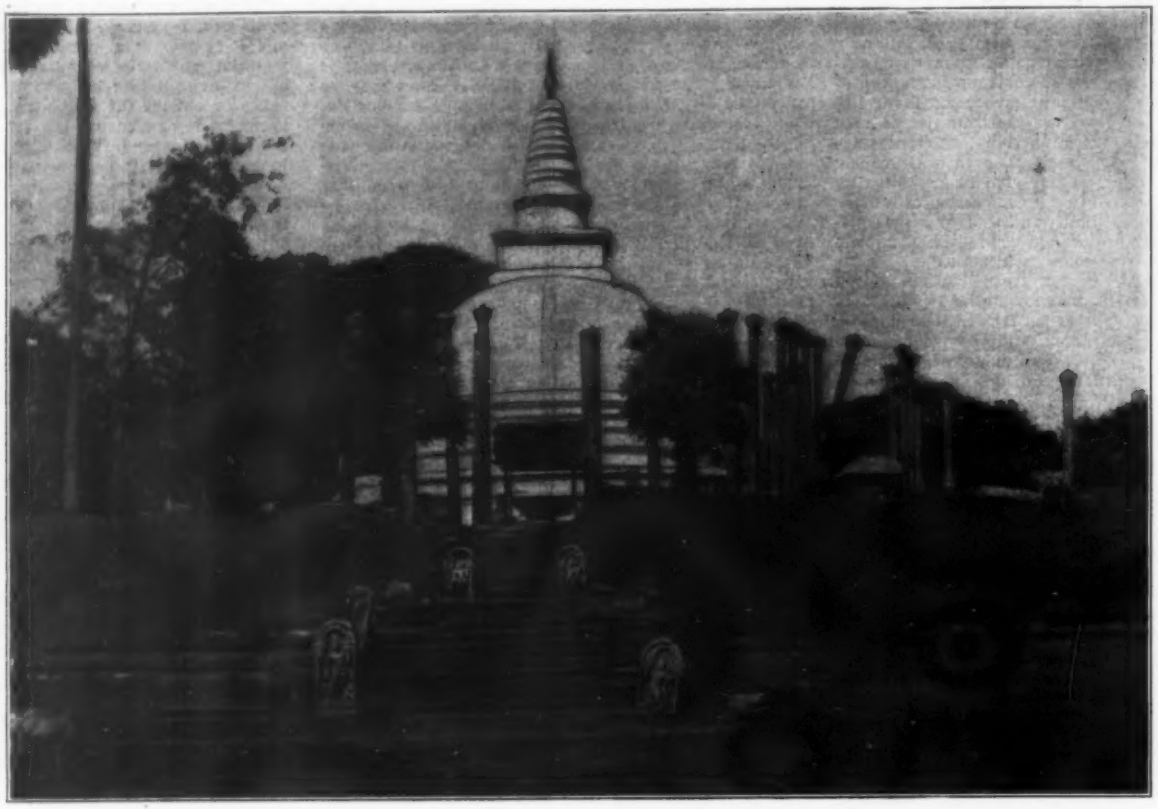
THE BURIED CITY OF CEYLON.

(*Continued from first page.*)

were erected by kings to commemorate different events

Sir Edwin Tennent says of one of them: "Even with the facilities which modern invention supplies for economizing labor, the building of such a mass would at present occupy five hundred bricklayers from six to seven years and would involve an expenditure of at least a million sterling ($5,000,000). The materials are sufficient to raise 8,000 houses, each with 20 feet frontage, and these would form thirty streets each

of the Jokunas, or bathing places. Simple, even severe, in design, they are found near the sites of all the important buildings. Those which have been restored are beautiful in their simplicity and proportions. Before each of the buildings, and taking the place of the threshold, is one of the most unique remains of this ancient civilization. Although different in beauty and workmanship, they are all nearly the same. They have



THIS DAGOBA IS THE RESTING PLACE OF THE RIGHT COLLAR BONE OF BUDDHA. IT IS THE OLDEST MONUMENT IN INDIA OR CEYLON, AND WAS RECENTLY RESTORED. THE PILLARS SEEN IN THE PICTURE ORIGINALLY SUPPORTED A CANOPY OVER IT.

—one to celebrate the conquest of a rival, another to the glory of Buddha, and so on.

In the hot, dry atmosphere of Egypt they would be as perfect as two thousand years ago, but in Ceylon the hot summers and the rainy winters have very nearly proved too much for them.

Birds have dropped seeds in their flight, and these,

half a mile in length. They would construct a town the size of Ipswich or Coventry; they would line an ordinary railway tunnel 20 miles long, or form a wall one foot thick and ten feet high, reaching from London to Edinburgh." How long it took the original builders to construct these monuments is entirely a matter of conjecture.

been dubbed "Moonstones," and that inexpressive term has to do duty for something both beautiful and artistic.

In shape they are half circles, but words cannot do justice to the beauty and originality of the design. In concentric circles come first the border of lotus leaves, then a procession of lions, horses, Brahmany

A VIEW OF THE STEPS SHOWN IN THE PRECEDING PICTURE.

Illustrations from the National Geographic Magazine.

THE BURIED CITY OF CEYLON.

taking root in the cracks and crevices of the Dagobas, have grown until they have dislodged huge masses of brick, making frequent restorations necessary.

Originally these mounds were painted white with a composition called *chunam*, but now they resemble wooded hills from which in places the sides have fallen away, showing the bricks beneath.

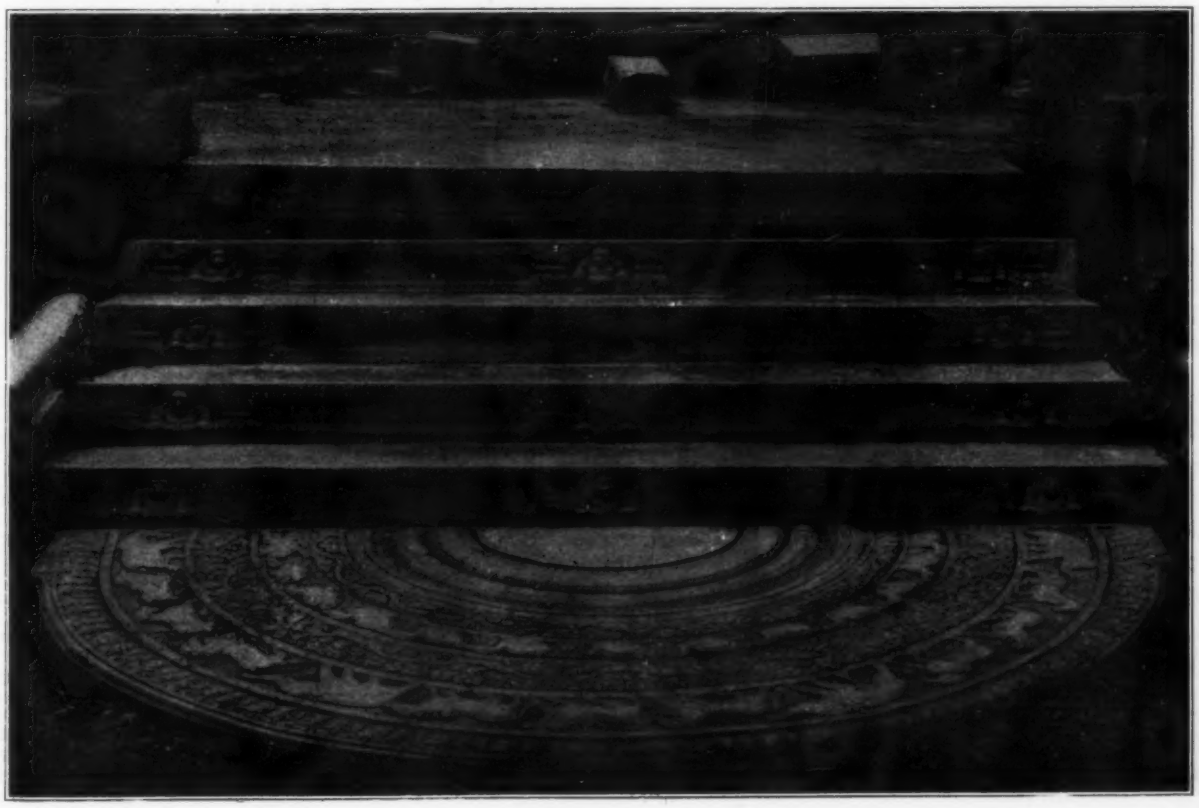
Besides the Dagobas, there are many other objects of interest, not the least of which are the "Yogi" stones, divided into nine or twenty-five squares, at which the Buddhist priests were accustomed to gaze in order to get their minds in a proper frame for contemplation of the Infinite.

One is greatly impressed by the number and beauty

bulls, and elephants (see picture); another design of lotus leaves, and inside that a similar procession of geese. The center is taken up by half of the conventional lotus flower.

Probably a majority of people will be interested most by the fact that here is the oldest tree in the world. Its age is about 2,200 years and is undoubtedly

ONE OF THE ANCIENT BATHING PLACES, ANURADHAPURA.



THE THRESHOLD OF ONE OF THE BATHING PLACES, ANURADHAPURA.

Illustrations from the National Geographic Magazine.

THE BURIED CITY OF CEYLON.

and spared by all. During its lifetime most of the world's history has been made. It was already old when Christ brought his message to the world, and standing in its present spot it witnessed the rapid rise of Anuradhapura and saw it sink to its present position of ruin and oblivion.

The accompanying illustrations are all from photographs taken by the author in Ceylon. The tooth of Buddha, which is said to be preserved in the temple shown in one of the engravings, is visible only once or twice a year, and at other times to distinguished strangers. People who have seen it say that it resembles more that of a crocodile. The original, according to unbelievers, was destroyed by the Portuguese.—From the National Geographic Magazine.

THE ETHICS OF JAPAN.*

By BARON KENCHO SUYEMATSU, B.A., LL.M.

I HAVE been asked by your council to read before you a paper on the ethics of Japan, and this is my attempt in response to that request, though very imperfect it must necessarily be.

There are three sources of factors which influenced the molding of the ethical system in Japan, namely, Shintoism, Buddhism, and Confucianism. The first is the native religion of Japan; the second is, needless to say, a religion originated in India and introduced to Japan through China and Korea, and the third is the moral teaching of China. As to the relative positions of these three, I have already fully explained this in an article entitled "The Religions of Japan," in the December number of the Independent Review. They are not antagonistic to one another, as people not living in Japan might imagine, and as would only appear natural to them from their own notions of religion. Of these three, Buddhism is the most religion-like in the ordinary sense of the term. Shintoism ranks next, but it is very simple and liberal if viewed in the light of a religion. Confucianism comes last; it is ordinarily classed by Western writers as a religion, but as a matter of fact its religious aspect is very vague, and it is not considered a religion by the Orientals. Perhaps a better term for it would be the Chinese teaching of morality, because moral notions which can be gathered from Chinese study are comprised in all sorts of Chinese writings, and Confucius, the great sage, is only one of the exponents thereof. Confucius, however, takes a very high place among those exponents, and therefore he came to be revered more than any others by Orientals, and thus Chinese teaching came to be usually associated with the name of the great sage. I cannot do better than follow this

* Reprinted from Journal of the Society of Arts, London.

example and call Chinese teaching by the name of Confucianism.

Comparing these three systems of teachings with regard to ethics, Confucianism stands out very prominently in its systematic exposition and practical utility. Buddhism, it is said, is very philosophical, and deep in its ideas of the cosmos, and there is no doubt that it is capable of exercising a great influence on the popular notion of a future life, though it does not do so as much in Japan as in some parts of the Asiatic continent. It has, however, very little to say with regard to ethics relative to the actual life of the human being. It says you must not do wrong; it says you must do good; but as to what is good or what is bad it is very vague in its meaning. It suggests rather religious notions than practical ethics, how one should behave in this world toward one's fellow creatures or toward the community or state to which one belongs. It speaks of ten warnings and four benevolences. The ten warnings are: 1. Do not kill the living. 2. Do not steal. 3. Do not commit adultery. 4. Do not speak wantonly. 5. Do not make sensational exaggerations. 6. Do not calumniate. 7. Do not use a double tongue. 8. Do not be greedy. 9. Do not be angry. 10. Do not entertain crooked views.

The four benevolences which one has to remember are: 1. The father and the mother. 2. The ruler of the land. 3. "All beings." 4. The three treasures, i.e., the Buddha, the laws, and the priesthood (order).

It speaks of compassion and forbearance. It also speaks of eight correct ways: 1. Correct views. 2. Correct thoughts. 3. Correct words. 4. Correct conduct. 5. Correct living. 6. Correct ministration, meaning self-reflection and aspirations. 7. Correct conception. 8. Correct mediation. In their essence, however, all these teachings are mostly of negative character, and, moreover, I must say that they have more importance from a religious point of view than from an ordinary and a practical ethical point of view. Therefore I can say that Buddhism has very little to do with the ethics of Japan in the sense of a systematic exposition of them, though in an indirect way it has had some influence on the moral atmosphere of the Japanese, as I shall show later on.

The Chinese teaching, otherwise called Confucianism, is a system of moral teaching founded upon a patriarchal system of community. It does not, therefore, only speak of the good conduct of an individual as relating to his fellowship with other individuals, but also from the point of view of the whole system of community as a state. Therefore it speaks of modes of governing and of being governed, as well as of individual relationship between man and man. It does not recognize any difference between sovereignty and ruler, nor does it notice a difference between state and country. In it the greatest natural bonds of humanity are five, and they are: (1) Sovereign and subjects; (2) father (implying also mother) and child; (3) husband and wife; (4) brothers (implying also sisters); (5) friends. To each of these relationships the essential duty which is to be borne in mind by each individual is separately attributed, and to each of these duties a special term is given to designate its actions from the point of view of a virtuous nature. Besides these five relationships there are two other relationships which have to be added, namely, the relationships between the elder and the younger, not necessarily meaning brothers, and also the relationship between master and pupil. The term "the sovereign and subjects," in Orienfal notions, signifies in their bearing a very deep meaning in their mutual relationship. I once heard from a very trustworthy authority that a Western diplomatist, well versed in Oriental affairs, had said that the Oriental idea concerning sovereign and subjects was not and could not be thoroughly understood by Occidentals, and I think that remark is not far from the truth.

The idea of the best virtue that a sovereign can have is "jen," meaning to be as humane as possible to his subjects, detesting oppression, giving the best administration to his country—in a word, to be the best ruler that ever ruled a land. The idea of the best subject is loyalty. The idea of that of father and son is filial piety on the part of the child and strictness on the part of the father, which is modified in the case of the mother toward tenderness, for which there is a special term. The idea which governs the relationship between man and wife is harmony. The older word for this was "distinction," meaning "not to be unseemly," but the word "harmony" is also used sometimes, and we Japanese prefer it. The idea of that of brothers and sisters is brotherly friendship, for which also a special word exists. The idea of that of friends is trustworthiness. In this way all the five cardinal bonds are dictated by desirable manifestations of sympathetic attentions to one another. But of course more prominence is given to the virtue of a subject, a child, or younger brother, in the case of a sovereign and subjects, of parents and children, and of brothers, respectively. Then, again, the elder and the younger in general are expected to respect each other as the case demands, and the relationship between them is to be regulated by a term which is equivalent to the English word "order"; that is to say, the younger should not seek to supersede the elder, but to pay respect to him, while the elder is expected not to take advantage of the younger, but to treat him with kindness. The relationship between master and pupil is also regarded as very important. The pupils are expected to respect their masters almost as much as their parents, while the master is expected to treat his pupils with parental kindness; no businesslike thought is to enter their minds. In the olden times in the East the system of teaching and learning was very different from that which exists in these modern days. The teacher taught his pupils out of the love of imparting his knowledge and virtuous example, as well as the doctrinal principles he entertained, while the pupils were supposed to gather around him out of their admiration for the personality of their master and for the purpose of receiving his instructions and influence for their personal improvement and future usefulness. Such being the case, it was no wonder that the relationship between a master and his pupil was regarded with so much importance in ethics.

Apart from these classifications the virtuous attributes of man are spoken of in several other ways. We have first of all "wisdom, humanity, and courage." These three are considered to be the three greatest traits of character to be embodied in one person. Wisdom may not exactly fall under the category of a virtue in its strictest sense, but I suppose we need not be very critical on this point. In this instance humanity—that is, "jen" in the Chinese original—may be interpreted as comprising every other virtue besides mere mercifulness. There is another catalogue, viz., "humanity, justice, decorum, wisdom, and faithfulness." These five are considered essential elements of virtue for regulating a community, and should be observed by each member of it. There is another—"filial piety, brotherly friendship, loyalty, and faithfulness"; these give guidance to a man in his capacity of a son, a brother, a subject, and a friend. There is yet another—"sympatheticability, goodness, respectfulness, self-restraint, and modesty." These are virtues considered important as regards one's self-control. As to the women, "quietness, modesty, and purity" are considered the ideal traits of their character, besides all those which I have just described above, which are of course applicable to women to an extent almost equal to men.

In the West the term love plays an extensive part in governing all the mutual relationships of the kinds enumerated above. The essence of Oriental ideas does not differ from it in its purport, but expressed in words the word love does not play so extensive and imperative a part as it does in the West, because in the Confucian doctrine different technical terms are used, as we have already seen, to meet each particular case. The word love is used very sparingly in the Confucian books, and it is used more especially for designating one kind of virtue, as, for example, "extensive love," meaning philanthropy in the Western sense. The word "jen," which ordinarily may be translated as humanity, more resembles the Western word love, because that word "jen" may be interpreted in many ways suitable to the occasion on which it is used, almost in the same way, and in a similar sense, that the word love can be used. But the meaning of that word "jen" is more comprehensive and deeper because it implies some other meaning than mere attachment. I will not worry you by going into full details of the interpretation of that word, as it is too technical. There is, however, one thing worth noticing about the word love in Chinese. When that word is singled out it is also applicable to many cases, including the relationships above enumerated. Thus it can be used in a very comprehensive manner, and thence there arises a question about the essence of the word. The question is whether the notion of love is absolute, and consequently has no gradation or differentiation in its nature. At the time of Mencius, some time after Confucius, there was a school of philosophers who maintained that there ought not to be any differentiation, but Mencius maintained that that was a fallacy. The word may be the same, but the practice may be differentiated according to the circumstances. The meaning is that one should love a nearer object more than a distant one, and thus the ethical notion of cosmopolitanism was reconciled with other notions of different virtues—in other words, if one does good to his neighbor more than to a stranger, or if one does more good to his country than to other lands, out of the feeling of love, it is quite justifiable from an ethical point of view, and thus Chinese ethics are made reconcilable with

ONE OF THE DAGOBAS AT ANURADHAPURA. THE CITY WAS CHOSEN CAPITAL BY KING PONDUKABHOYA IN 437 B. C. AND REMAINED THE CAPITAL OF THE ISLAND FOR TWELVE CENTURIES.

From the National Geographic Magazine.

THE BURIED CITY OF CEYLON.

the principles of state. And this is, I think, an important landmark in which Confucianism differs from the features of an ordinary religion, which in its essence is, as a rule, founded upon cosmopolitanism, and knows not an artificial boundary of states.

There is a Chinese maxim which says: "No loyal subject serves two masters, and no virtuous woman sees two men." The cardinal points of the Chinese ethics are loyalty and filial piety; so that, although all sorts of virtues are inculcated, greater importance is placed on these two points. In China, learning means studying moral teaching. There are, of course, many subjects for study, but moral notions pervade every branch of literature. It is so, even with history; Chinese histories, as a rule, record only events as they occur; they have no historical or political observations, and any observations made by the writers are written in such a way as to draw attention from a moral standpoint. Their histories, therefore, have very little value in the ordinary sense of history as the term is employed among Western nations, but the fact remains that they pay much attention to moral lessons. Their expositions of moral teachings are done more in the way of philosophical or scholastic dissertations. The ethics of China, however, were not necessarily identical throughout the long period of her history, extending over several tens of centuries. There were several schools of philosophers besides Confucius, some of whom even went so far as to differ from him in many points; and also the interpretations of Confucianism differed at different epochs. But the chief feature of his teaching has always remained the same, and all that I have said about it above represents fairly the idea of Confucian doctrine. It is natural that Confucianism should be regarded as a sort of religion, because its followers respect it almost as a believer in religion respects his creed; moreover, Confucianism recognizes in a measure the existence of some supreme power. It speaks of heaven in the sense of a power; it speaks of the "order of heaven"; it even speaks of the "supreme emperor," meaning the Supreme Being. It also recognizes the immortality of the soul, though in a vague manner, and pays great attention to festivals given in honor of one's ancestors; to use a common phrase, it worships the ancestors. But the parts of Confucianism which relate to the future of man only form a subordinate element of it, so much so that Confucius himself once said: "I do not yet know the living; how can I know the dead?" At all events I, in common with most Orientals, do not regard Confucianism as a religion in its ordinary sense. There are, of course, many customs and matters of etiquette sanctioned by Confucianism, or rather enforced by it, which are absurd or impracticable in the eyes of the Japanese, but there is no necessity for me to dwell upon these shortcomings here.

Let us now see what is Shintoism. It is essentially indigenous to the soil of Japan. It may be regarded as religion, and if it be a religion it is certainly of a unique kind, having nevertheless much similarity to the ancient cults of the Greeks and the Romans. It has no founder, nor has it any dogmas, in the ordinary sense of a religion. It has grown up with the customs and traditions and general characteristics of the nation. It recognizes the immortality of the soul; it acknowledges the existence of supernatural powers; it reverences the ancestral spirits, and therefore it may be called a religion of ancestral worship. In that respect it resembles Confucianism. It concerns itself, however, with temporal affairs far more than with spiritual affairs. In this respect also it very largely resembles Confucianism. It has existed in Japan from time immemorial, long before the introduction of Confucianism and Buddhism.

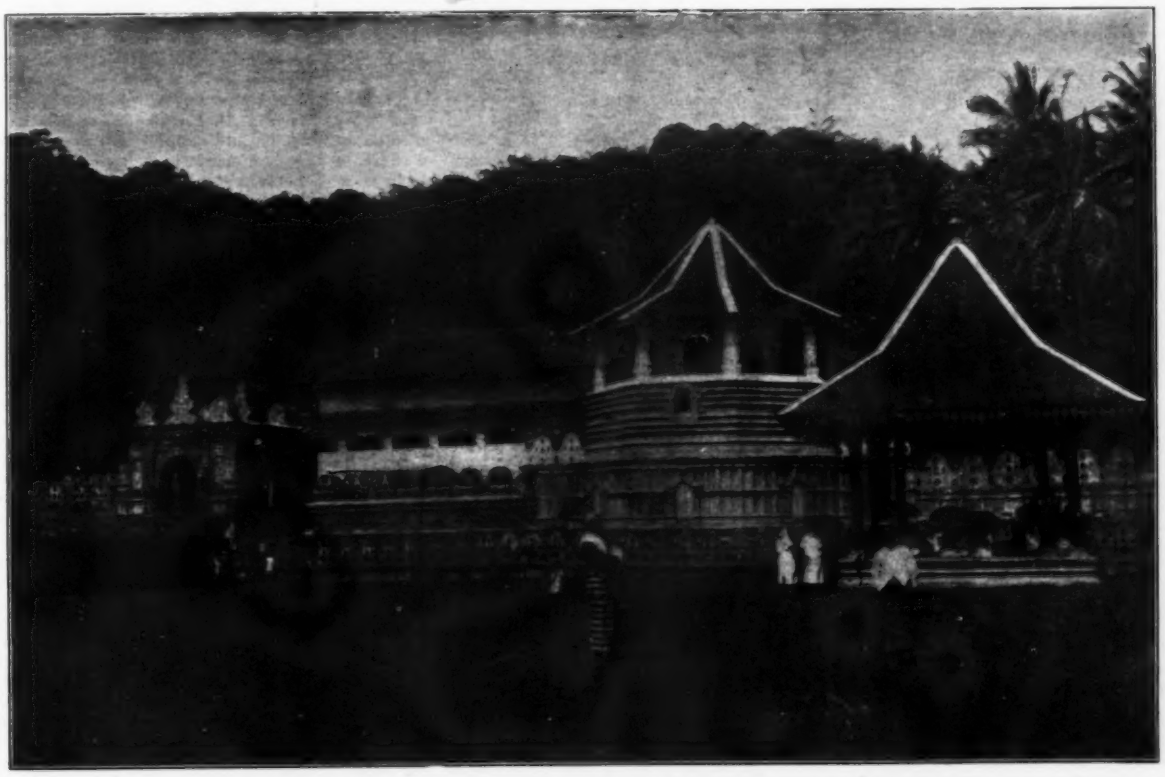
From an ethical point of view it has more teaching in it than Buddhism, but it is not so elaborate as Confucianism. Nevertheless it has a tight grasp of the Japanese mind. It is supremely content with its simple tenets, so much so that a well-known scholar, who was a devout supporter of it, when speaking of its ethical teaching in comparison with Confucianism, once said that "We do not want so many nomenclatures as Confucianism requires to signify all sorts of virtues and good conduct, and our simple teaching is quite enough to cover all."

Shintoism is also based upon a patriarchal form of community. Its essential notion of ethics is cleanliness of conscience; but the idea of cleanliness is applied not only mentally, but also physically—hence its tendency to bodily cleanliness as well as other cognate matters. It speaks of good and bad; it designates bad minds as "black" or "muddy," and good minds as "red" or "clear." Its ideals of conduct are honesty and straightforwardness. It reverences its ruler from the very nature of its cult, and a magnificent ideal of a subject and a citizen is developed from these simple notions.

Such are, then, the three great sources of Japanese ethics. It is like the foam produced by currents of water. The water is the source, but when foam is produced it differs from actual water. So Japanese ethics are produced by the intermingled notions of these agencies, but they are no longer of the same substance as their source. I mean to say that our ethics have formed their shape quite independently of the orthodox or dogmatic parts of any religion, and people regard them as such in the same way as one would ordinarily regard foam as differing from water. I will now explain how this has been brought about. From about the sixth century of the Christian era Chinese study was introduced into Japan, and almost simultaneously Buddhism was also introduced to our country. The study of Chinese, as I said before, means the study of Chinese ethics, and I may say that Chinese has become almost like our own literature, though we had our vernacular literature coexisting. The study of Chinese, therefore, meant the introduction of Chinese ethical notions, in the same way as the study of Greek or Latin introduced Greek or Roman notions into European countries. This, however, did not mean that it supplanted our own ideas of morality, but it rather supplemented and augmented our notions in so far as it concerned the nomenclature and classification of different ethical virtues. We did not mean to make ourselves slaves to Chinese notions, we rather utilized Confucianism; and therefore Confucianism, as interpreted in Japan, is not the same as Confucianism in China. There is a story told of a Japanese professor, who was a deeply read Chinese scholar, and his pupils. The master once asked his pupils: "Suppose China invaded Japan with an army led by Confucius himself as the generalissimo, and assisted by Mencius as his lieutenant; what would you do?" The pupils replied: "It would be our bounden duty to take up arms unhesitatingly for our country and beat and crush them to pieces." Thereupon the master smiled and expressed his glad assent. This will show how we interpret Chinese teaching.

Then also Buddhism, poor as it is in ethics, has contributed something toward forming our national character, in that it has indirectly assisted in inculcating gentleness and also kindliness to living beings. I may go a step further. Buddhism itself, as interpreted in Japan, is not the same Buddhism as it was originally. It had to accommodate itself to the requirements of the country. Then, also, Buddhism in China and Japan is studied in books which are translated into Chinese, and therefore the priests who study their own religion have also to study Chinese, which, I repeat, involves the study of Confucianism, and therefore they are familiar with that teaching. The Japanese priests, therefore, made use of Shintoism and Confucianism in their own teaching on any points where they found their own teaching was deficient—that is to say, they did so in practical and moral teaching. And not only that; we notice even the dictum of Buddhism itself is sometimes modified to suit such purposes. I mentioned above four benevolences spoken of in Buddhism as being "the father and the mother," "the ruler of the land," "all being," and "the three treasures." I do not know whether this is to be found in the Sanscrit original; I think it is not. It sounds more like a Chinese Buddhistic notion. It is still further modified in an old Japanese book as "heaven and earth," "the ruler of the land," "the father and the mother," and "all beings." And thus for "the three treasures" is substituted "heaven and earth." This occurs in a passage which is put into the mouth of a famous Shigemori in a discourse which he made when he severely admonished his father, Taira-no Kiyomori, though with filial tenderness, when the latter had behaved badly toward his sovereign the Emperor. The passage is to be found in a famous book written in the middle of the fourteenth century by Kitabatake Chikafusa, who was a court noble, a royalist, and a man with much knowledge of Buddhism.

(To be continued.)



IN THIS TEMPLE THE TOOTH OF BUDDHA IS SUPPOSED TO BE PRESERVED—KANDY.

From the National Geographic Magazine.

THE BURIED CITY OF CEYLON.

GOLD AND SILVER PRODUCTION IN THE UNITED STATES.*

By WALDEMAR LINDGREN.

THE production of gold and silver in the United States in 1905 is shown in the first table on the following page in approximate distribution by States and Territories. These figures are the result of conference and adjustment between the Geological Survey and the Bureau of the Mint, and are accepted as final by the two bureaus.

The output of gold and silver in the United States is ascertained by the Geological Survey by the method of "mines report," that is, by direct inquiry from the producing mines. On the other hand, the Bureau of the Mint collects its data concerning the two metals by recording the quantities and sources of bullion deposits of the United States mint and assay offices, and by statements from the smelting and refining establishments detailing the quantities and sources of the metals produced. Statistics obtained by these different methods agree strikingly in the totals for the United States, but differ more or less in detail. Some of the reasons for this are set forth more fully in the following page. Perhaps the most important factor is that of "stock in hand" of the reduction works at the end of the year. Some of the largest discrepancies have been traced to this source, and this part of the problem will be treated more fully in the statistics for 1906.

* Abstracted from a Bulletin published by the United States Geological Survey.

Both methods are indispensable for a correct estimate of the actual distribution by States and districts.

The following table contains the figures accepted as final. In this table gold is calculated at $20.671834 per fine ounce and silver at 61 cents per fine ounce.

APPROXIMATE DISTRIBUTION, BY PRODUCING STATES AND TERRITORIES, OF THE PRODUCT OF GOLD AND SILVER IN THE UNITED STATES FOR THE CALENDAR YEAR 1905.*

[Fine Ounces.]

State or Territory.	Gold.		Silver.		Total Value (Silver at Commercial Value).
	Quantity	Value.	Quantity	Commercial Value.	
Alabama	2,008	$41,500	300	$183	$41,683
Alaska	727,026	14,925,600	169,200	103,212	15,028,812
Arizona	130,192	2,691,300	2,695,700	1,589,477	4,280,777
California	928,660	19,197,100	1,043,000	639,020	19,857,120
Colorado	1,243,291	25,701,100	12,94:,800	7,895,108	33,596,208
Georgia	4,687	96,900	900	549	97,449
Idaho	52,032	1,075,600	8,125,600	4,956,616	6,032,216
Maryland	716	14,8 00	100	61	14,861
Michigan	.....	.....	253,000	154,330	154,330
Missouri	.....	.....	12,900	7,869	7,869
Montana	236,520	4,889,300	13,454,700	8,207,367	13,096 667
Nevada	259,246	5,359,100	5,863,500	3,576,735	8,935,835
New Mexico	12,858	265,800	354,900	216,489	482,289
North Carolina	5,994	123,900	13,200	8,052	131,952
Oregon	60,222	1,244,900	88,900	54,229	1,299,129
South Carolina	4,600	95,100	100	61	95,161
South Dakota	334,460	6,913,900	179,000	109,190	7,023,090
Tennessee	160	3,300	95,500	58,255	61,555
Texas	92	1,900	417,300	254,493	256,392
Utah	248,491	5,140,900	10,319,800	6,295,078	11,435,978
Virginia	242	5,000	200	122	5,122
Washington	17,889	370,000	119,400	72,834	442,834
Wyoming	1,146	23,700	2,700	1,647	25,347
Total	4,265,742	88,180,700	56,101,600	34,221,976	122,402,676

* Gold value: $20.671834 per fine ounce. Silver value: 61 cents per fine ounce.

INCREASE (+) OR DECREASE (—) IN PRODUCTION OF PRECIOUS METALS IN THE UNITED STATES IN 1905, BY STATES AND TERRITORIES.

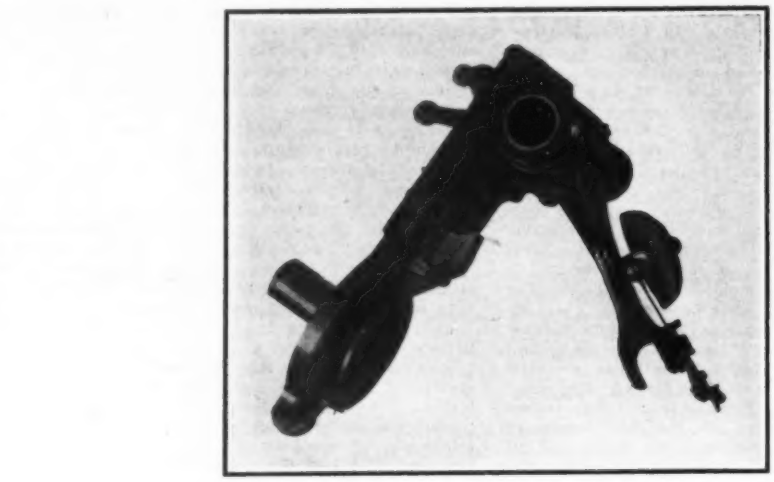
[Fine Ounces.]

State or Territory.	Gold.		Silver.	
	Quantity.	Value.	Quantity.	Value
Alabama	+ 391	+ $12,300	+ 100	+ $67
Alaska	+ 278,897	+ 5,765,100	— 29,500	— 12 034
Arizona	— 31,569	— 652,600	— 138,400	— 2,101
California	+ 9,787	+ 202,300	— 359,300	— 175,934
Colorado	+ 63,144	+ 1,305,300	— 1,388,800	— 417,220
Georgia	— 1	.....	— 600	— 321
Idaho	— 20,710	— 428,100	+ 315,400	+ 426,700
Maryland	+ 600	+ 12,400	+ 100	+ 61
Michigan	.....	.....	+ 123,200	+ 80,206
Missouri	.....	.....	+ 12,900	+ 7,869
Montana	— 10,686	— 208,500	— 1,153,400	— 265,331
Nevada	+ 50,856	+ 1,051,300	+ 3,198,400	+ 2,013,577
New Mexico	— 5,617	— 116,100	+ 140,300	+ 92,021
North Carolina	.....	.....	— 1,600	— 532
Oregon	— 3,144	— 65,000	— 44,700	— 23,027
South Carolina	— 1,392	— 28,700	— 400	— 229
South Dakota	— 5,325	— 110,700	— 8,000	— 730
Tennessee	— 48	— 1,000	+ 86,300	+ 22,919
Texas	— 18	— 400	— 53,400	— 17,876
Utah	+ 44,789	+ 925,900	— 2,164 300	— 945,816
Virginia	+ 98	+ 1,200	— 6,500	— 3,764
Washington	+ 2,097	+ 42,100	— 30,500	— 14,108
Wyoming	+ 353	+ 7,300	— 1,700	— 905
Total	+ 373,262	+ 7,716,000	— 1,581,200	+ 765,952

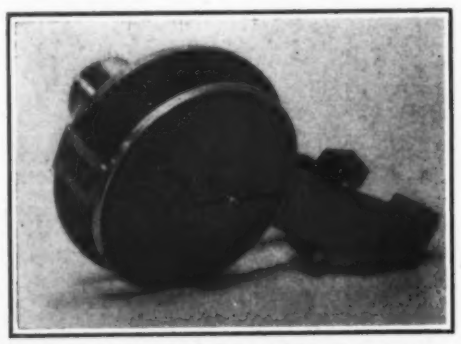
The production of gold in the United States for 1905 was 4,265,742 fine ounces, or 132,680 kilogrammes, equivalent to $88,180,700. This represents an increase of 373,262 ounces, or $7,716,000, over the production of 1904. The rapid advance in gold production which began in 1892, but temporarily halted from 1901 to 1903, was resumed in 1904. This increase in 1904 over the output of 1903 was approximately $7,000,000, and in all probability the increase in 1906 over 1905 will be at least the same amount. The chief sources of the great increase are as follows: Alaska added about $6,000,000 to its output of $9,160,458 in 1904, and Colorado, Nevada, and Utah added about $1,000,000 each to their product of the previous year. On the other hand, decreases are noted in Arizona, Idaho, and other States. The States producing over $1,000,000 in gold rank at present in the following order: Colorado, California, Alaska, South Dakota, Nevada, Utah, Montana, Arizona, Oregon, and Idaho.

The production of silver in the United States for 1905 was 56,101,600 fine ounces, or 1,713,852 kilogrammes, equivalent to $34,221,976, at an average price of 61 cents per fine ounce. In comparison with the figures of the Bureau of the Mint in 1904, this represents a decrease of 1,581,200 ounces, but in spite of this the increase in the average price of 4 cents per ounce (from 57 in 1904 to 61 in 1905) effected an addition to the value in 1904 of $765,952. Two years of better prices for silver have thus far failed to stimulate the production. The record figures were attained in 1892, when the output was 63,500,000 fine ounces, valued at $55,662,500. A still further advance to a maximum of somewhat over 70 cents has taken place in 1906, but it is not likely that the year will show startling additions to the output for 1905. The increase should be more marked in 1907, and will probably be rather derived from copper ores and dry silver ores than from lead ores.

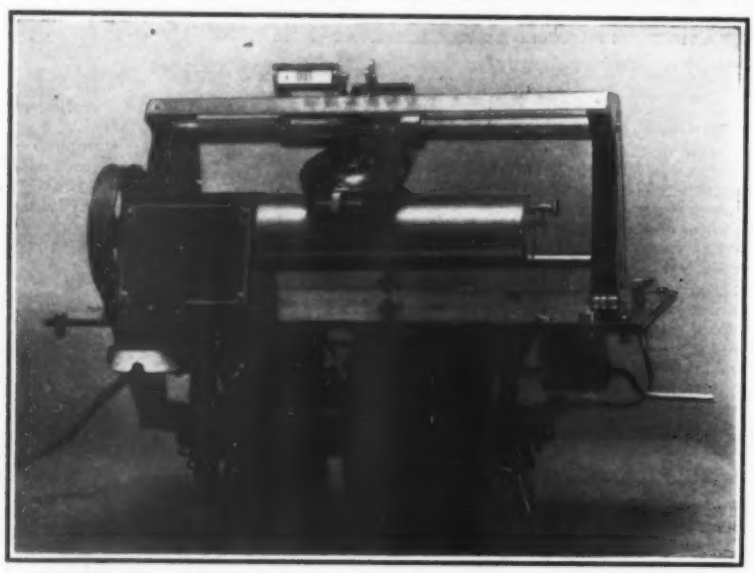
The decrease in the quantity of silver is specially noticeable in Colorado and Utah; to a slight degree also in Montana. On the other hand, Nevada and Idaho materially increased their output. The States producing over 1,000,000 ounces rank at present as follows: Montana, Colorado, Utah, Idaho, Nevada, Arizona, and California.



DETAIL OF CARRIAGE, SHOWING RECORDER IN POSITION.



RECORDER-REPRODUCER, SHOWING RECORDING AND REPRODUCING POINTS ON SAME DIAPHRAGM.



COMMERCIAL GRAPHOPHONE OPERATED BY ALTERNATING CURRENT MOTOR.

A COMMERCIAL GRAPHOPHONE FOR RECORDING DICTATION.

THE commercial graphophone, which has been lately introduced to supplant the stenographer, was first invented by Prof. Charles Sumner Taintor and Dr. Chichester Bell, working in conjunction with Prof. Alexander Graham Bell, inventor of the telephone, in Washington, D. C. The place was the Volta Laboratory.

The first commercial graphophone was a very crude thing, operated by a treadle similar to a sewing machine. The cylinders were made of pasteboard with a thin coating of wax. The new commercial graphophone embodies the principles which were discovered by the eminent scientists named, and embodies all the mechanical perfections which have been the result of six years of experimenting.

The machine is composed of two main parts, viz., the motor and the main.

The motor consists of the motor and the frame for holding the same.

The main consists of a mandrel on which the wax record blank is held, the carriage which holds the recorder-reproducer, and feed screw, the feed nut, the necessary gearing for operating these parts, and the main frame.

The motive power of the machine is supplied by a low-voltage direct-current electric motor, which can be used on varying voltages by means of proper resistance (ordinarily an incandescent lamp).

A belt connects the motor pulley with the mandrel pulley, thereby causing the latter to revolve when it is engaged with the start and stop clutch.

A train of gearing operates the feed screw, which causes the recorder-reproducer carriage to travel from left to right when the feed nut engages with the thread of the feed screw.

The feed nut is regulated by means of a lever. When this lever is raised it releases a spring, causing the feed nut to mesh with the feed screw; when the lever is lowered it forces the feed nut away from the feed screw, thereby compressing the spring.

The speed of the machine (normally about 80 R. P. M.) is regulated by a speed screw. This speed screw causes a flexible shaft to apply or release pressure on a friction disk, thus allowing the governor springs to expand or contract, generating correspondingly greater or less centrifugal force, either accelerating or diminishing the speed of the motor.

This description applies to about all types of graphophones.

The important features of the commercial graphophone are the recorder-reproducer, the start and stop mechanism, and the signaling device.

The recorder-reproducer is known as a combination recorder-reproducer because the recording stylus (sapphire) and the reproducing stylus (sapphire) are set in the same holder which is fastened to one diaphragm (mica). This same diaphragm receives the vibrations to be recorded and also receives the reproduced vibrations, thus performing a double function.

The recording or reproducing stylus is brought to bear on the wax blank by means of a lever operating a ratchet segment, which meshes with a rack cut on a carrier slide controlling movements of recording and reproducing stylus, also simultaneously operating the indicator.

The indicator is a triangularly shaped part. One side reads "out," indicating that neither the recording nor reproducing stylus bears on the wax blank and that the carriage is not in motion; one side reads "recorder," indicating that the recording stylus is in contact with the surface of the blank and that the feed nut is in mesh with the feed screw; the third side reads "reproducer," indicating that the reproducing stylus is in contact with the surface of the blank and that the feed nut is in mesh with the feed screw.

The start and stop attachment is generally operated by pneumatic pressure, but can also be operated by means of push buttons. The same results are produced in either case.

The operator causes the mandrel to revolve at will by either pressing or lifting his foot on the rubber bulb (air reservoir). When he presses the rubber bulb, the piston is forced into a small cylinder to operate a shaft connected with the start and stop clutch, causing the clutch to mesh with the ratchet on the mandrel pulley. The mandrel is now revolving, and the record blank is ready to receive the dictation or to reproduce what has been recorded.

By releasing the foot pressure on the bulb the piston is drawn back into the cylinder by the suction created by the return of the air to the bulb, thereby throwing out of mesh the mandrel pulley and clutch, which instantly stops the revolution of the mandrel.

The signaling device is a small bell and hammer, similar to those in use on a typewriter. When the reproducer carriage reaches 50 on the scale bar, a boss on the bedplate of the machine trips a hammer which strikes the bell. This indicates that the end of the blank has been reached.

SINGLE-PHASE VS. THREE-PHASE POWER TRANSMISSION.

By ERNEST VAN LOBEN SELS.

IT has become an accepted principle among electrical engineers that mathematically one-quarter of the copper in a transmission line is saved by the use of three-phase transmission. Of course, there can be no doubt that three-phase transmission requires one-quarter less copper for the same voltage between the wires than the single or two-phase system, but it is worth while to see how that saving is effected.

Since the copper in any given system varies inversely as the square of the voltage, and since the limit to higher voltages is only the capability of the insulation to withstand the increased strain, it follows that the condition for comparison of single with three-phase transmission must be an equal strain on the insulation in either case.

Now, in wet weather—and this is the most unfavorable condition for the insulators, and, therefore, the one to be considered—the pole and cross-arms become conductors connected to earth, and, therefore, their potential is and remains zero throughout the cycle, regardless of any inequality of leakage over the insulators. In dry weather the sum of the leakages from all the insulators on one pole, which would be zero in any balanced system if the insulators were all equally clean, may affect the potential of the pole to some extent, due to an unequal accumulation of dirt and moisture on the insulators, making the potential rise and fall in step with the wire over the dirtiest insulators. In practice, however, this effect will be small compared to the line voltage, because (a) the insulators must be kept clean enough to minimize the leakage in order to avoid destructive carbonizing; (b) the leakage would be very small in dry weather, as the dry dirt is not a good conductor. What little variation there may be is likely to occur in both single and three-phase transmission, so that, both systems being affected alike, this variation from zero potential may be neglected, and the potential of the pole considered to be always zero.

The voltage which the insulators of a three-phase transmission line must be designed to withstand is, therefore, the maximum difference of potential between any one wire and the neutral. The insulators being merely a set of high resistances star-connected, and each insulator is subjected to the same strain as would each of a set of star-connected transformers. Of course, for purposes of comparison, while dealing with the same wave-form in the two systems, it is perfectly allowable to use the mean effective voltage instead of the maximum voltage, because they bear the same ratio to each other in both systems. Making this substitution, the insulators in a single-phase line with a line voltage $= E$, would each have to withstand $E/2$ volts, while, for the same voltage between the wires in a three-phase, star-connected line, each insulator would have to withstand $\frac{E}{\sqrt{3}} = \frac{E}{1.732}$ volts. If the voltage be raised on the single-phase line to $\frac{2E}{\sqrt{3}} = 1.155\,E$, the strain on the insulators would then be equal to that on those of the three-phase line with E volts between the wires. If E_3 and I_3 represent voltage and amperage in the three-phase line, and E_1 and I_1 the voltage and amperage in the single-phase line, then for a power of P watts at power-factor p, we have in the three-phase line $P = \sqrt{3}\,p\,E_3 I_3$ or $I_3 = \frac{P}{\sqrt{3}\,p\,E_3}$ and in the single-phase line $p = p\,E_1 I_1 = \frac{p\,2E_3}{\sqrt{3}} I_1$ or $I_1 = \frac{P\sqrt{3}}{2\,p\,E_3} = \frac{P}{\sqrt{3}\,p\,E_3} \cdot \frac{3}{2} \cdot : \frac{I_3}{I} = \frac{3}{2}$ for the same power, power-factor, and the same strain on the insulation. That is, the current in each of the two single-phase wires would be 50 per cent greater than the current in each of the three three-phase wires. Consequently the total current in all the wires of one system would equal the total current in all those of the other, and, under these conditions, the copper required would be the same for both systems.

Incidentally, the wires of the single-phase system would have to be spaced 15½ per cent farther apart if it is desired to keep the same factor of safety on the atmospheric dielectric—and it must be noted here that this is the only part of the whole system which would be subjected to a greater strain than would be incurred with a three-phase line with the same voltage between wire and neutral. The cross-arms would therefore be a little longer than would be necessary for our three-phase line—a trivial item which would be more than counterbalanced by rendering unnecessary the extra length of pole required to support the third conductor of a three-phase line.

In conclusion, then, it is evident that while for the conventional comparison with equal voltage between the wires, the three-phase system shows a saving of 25 per cent of the copper in the transmission line, this saving is not effected by any inherent superiority of this form of transmission, but is only secured by increasing the strain on the insulators; and that, if the voltage be raised on the single-phase system until the same strain is imposed on the insulators, then both systems require the same quantity of copper, but the single-phase system requires one-third less insulators, insulator pins, and lightning arresters. This means not only a smaller first cost for the single-phase line, but also one-third less insulators to keep clean and replace when broken, and less chance for a ground. Indeed, to claim any superiority for the three-phase system on the ground of saving in copper in this manner is on a par with advocating shallow trusses for bridge construction on the ground that metal is saved by shortening the vertical and diagonal members; and all the while not taking into consideration the fact that the strains in most of the members will thereby be increased, and that therefore any saving in metal is only effected at the expense of the safety factor.

In the transmission of power running high up into the thousands of kilowatts, this saving of one-third of the insulator pins and lightning arresters may not be worth taking into consideration as against the great advantages of the three-phase system; the greater starting torque of all three-phase motors, less tendency to hunt and get out of step, and the higher efficiency and lesser weight of both generators and motors. But in the transmission of power in small quantities the matter is entirely different. Experience has proved that small wires are objectionable because they break too easily. Consequently in transmitting only a few hundred kilowatts an amount of copper is used in excess of the requirements for the power transmitted. In such a case one-third of the copper can be saved by transmitting single-phase and using only two wires. The question of the advisability of transmitting single-phase will then depend on the use to which the power is to be put. For electric lighting purposes single-phase current shows some advantages over three-phase current because it is easier to balance the two sets of lights in a three-wire, single-phase system, than to balance the three sets of a three-phase, four-wire system. Similarly single-phase current is better for charging storage batteries or for any electrolytic purpose whatever, as it requires but one mercury arc rectifier as against three in the three-phase system—quite an advantage when small amounts of power are so used. Where there is no objection to a frequency of twenty-five cycles, single-phase current is vastly superior to three-phase for electric traction, as the former can be used directly, without the interposition of any other machinery than step-down transformers in the "single-phase"' railway motor—an ordinary series motor with laminated poles, and designed for minimum sparking. For long-distance traction this arrangement greatly reduces the size of trolley feeders and the number of sub-stations required, as well as eliminating all rotating machinery.

Furthermore, the single-phase railway motor, which is only recently on the market, has undoubtedly many other possibilities as yet unexploited. Thus it could undoubtedly be used for driving hoists and elevators, as its characteristics make it peculiarly fit for work requiring very high starting torque, and running at variable speed. In fact, it might even be adapted for operating machines in machine shops where the individual drive is introduced. Geared directly to its machine, all speed variation over any ratio desired could be obtained by varying the electromotive force delivered by a transformer, doing away entirely with resistance coils, as in a D. C. machine. In fact, it should compare well with D. C. motors in regard to average running efficiency, as its greater efficiency at low speeds should more than offset its lower efficiency at full speed. Then ordinary single-phase motors can be used for driving machinery that can be started up under no load, and where the load is constant, as, for instance, centrifugal pumps, fans, etc.; and single-phase rotary converters are entirely satisfactory for generating D. C. current. Also in small motors generally, where a friction clutch can be used and the motor started off by hand, single-phase current can be used.

On the other hand, where heavy machinery must be started under full load, and the load is intermittent, as in mills, for instance, a single-phase motor would be an impossibility, and the question of the advisability of transmitting single-phase where part of the power is to be used for such a purpose, would depend on the relative amounts of power to be used for this and for other purposes, more suitable to single-phase current—or whether the mills were so located that they could be supplied with D. C. current from one central substation in connection with a storage battery, for instance. This question must be solved with especial regard to the peculiarities of each individual case. Enough has, however, been said to show that the much-maligned single-phase transmission of power is not without its advantages, and that there is quite a field in small power transmission where it is superior to three-phase transmission.—The Journal of Electricity, Power, and Gas.

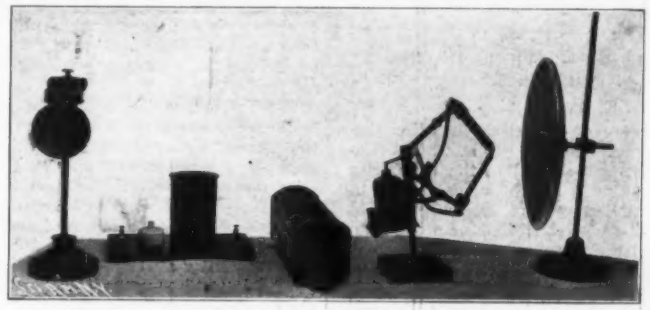


FIG. 1.—TRANSMITTER OF THE ELLA WIRELESS TELEPHONE.

ELLA SYSTEM OF WIRELESS TELEPHONY.

By EMILE GUARINI.

WIRELESS telephony still continues to occupy the attention of inventors; every year adds some new discovery; and the problem is daily making a step in advance. At present it is the turn of the Ella system, which has just been brought out by M. Ancil, of Paris In this system, the transmitter (Fig. 1) consists of an automatically-regulated arc lamp connected with a rheostat supplied by a continuous 110-volt current. This lamp is movable in all directions, and the two carbons, as well as the tension of the opposing spring, are regulatable. The lamp consumes six amperes with carbons of 13 and 8 millimeters diameter. It is capable likewise of being used in projection lanterns, and in such a case operates under from 35 to 60 volts. For wireless telephony an arc of from 15 to 20 millimeters is required, and this necessitates a tension of from 50 to 60 volts at the terminals of the lamp. The arc is centered in such a way as to be situated at the focus of a parabolic mirror of 30 centimeters aperture and 20 centimeters focus. In the circuit of the

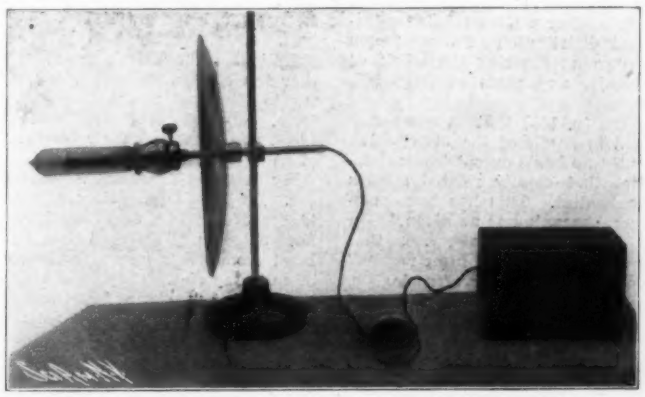


FIG. 2.—RECEIVER OF THE ELLA WIRELESS TELEPHONE.

lamp is interposed a transformer with the derivation of which is connected a microphone.

The receiver (Fig. 2) consists of a parabolic mirror identical with that of the transmitter and capable like it of sliding along a vertical rod. At the focus of this mirror there is a large-sized Ruhmer receiver connected with a series of dry batteries or of accumulators and a sensitive telephone. It appears that the apparatus, all the parts of which are nickel-plated, gives good results.

FACTS AND INTERPRETATIONS IN THE MUTATION THEORY.

By A. E. ORTMANN.

THE foremost champion of de Vries's mutation theory in this country undoubtedly is Dr. D. T. MacDougal, and he has largely contributed to the popularity of this theory. In a recent article[1] he takes up certain objections made by various writers, and attempts to show that they are without foundations or opposed to the known facts. But the criticism of the objections made by C. H. Merriam, D. S. Jordan, and the present writer fails to convince, and only serves to demonstrate that the vital points have been misunderstood.

Before I try again to give a review of my objections to de Vries's theory, I shall prove in detail that MacDougal's criticism of them, as well as those of Merriam and Jordan is unsatisfactory. It may appear as presumptuous when I take it upon me to talk in behalf of the latter two gentlemen, who are well able to take care of themselves,[2] but I may be excused on the ground that I hold precisely the same views, and am thus defending my own opinions.

I. MacDougal first takes up Merriam's contention, that the study of geographical distribution of animals shows no evidence of "mutation" (in the sense of saltation or discontinuous variation), since there are gradual transitions, which point to a progressive development of minute variations. This is not admitted by MacDougal, because he maintains (p. 209) that "once a mutant has appeared, no evidence of its distribution can be taken to account conclusively for its origin." Jordan has answered this in the article just referred to. But there is yet another aspect. Merriam did not express any view as to the *origin of mutation* (*saltation*); he only wanted to bring out the fact that mutations, in the sense of discontinuous vibrations, seem to be extremely rare in nature, which is indicated by the fact that, morphologically, varieties and even species are often very close to each other, and that if there are cases where a discontinuity is apparent, a closer investigation of the distribution, not only of the supposed mutant, as MacDougal puts it, but of the mutant and its allied forms, reveals the existence of intermediate forms.

With reference to this latter case, I should like to make a few additional remarks. Granted the existence of a connecting form between two extremes, which appear to fulfill the morphological requirements of mutation,[3] the question is, whether this connecting form represents a stage of development from one extreme to the other, or, as the de Vries school supposes, a hybrid between the extremes. This question in my opinion, may be settled in many, if not in all, cases, by the facts of the geographical distribution. If the overlapping area of the ranges of the two extremes is occupied by an intermediate form associated with the two original forms, hybridization is indicated; if, on the contrary, in the intermediate area the intermediate form is exclusively represented, the latter very likely marks a connecting step in the development from one to the other extreme.

I am much tempted to illustrate this here by an example I have discovered in the distribution of certain species of river crawfishes (group of *Cambarus propinquus*). But it would take up too much space to give all the facts. It will be presented to the public in due time; in fact, the paper is just now going through the press. Suffice it to say that both of the above cases are illustrated in this example, but that the final decision was possible only after a thorough investigation of the geographical distribution of these forms had been made, by researches covering the whole of the State of Pennsylvania, and parts of Maryland, West Virginia, and Ohio.

MacDougal further says (p. 209) that "a number of zoologists have assumed to speak of the distribution of plants, with apparently no basis except 'general information' to the effect that closely related species do not have the same habitat. This has been variously put, but the general meaning is as given." On page 210 he talks of this as "the idea . . . that closely related species do not occupy the same region." I believe I am included in this number of zoologists, although I never expressed such an idea; but since I do not know of any other zoologist who did, I think MacDougal refers to something similar I have said. I expressed it thus: "Two closely allied species never occupy absolutely the same *range* under identical ecological conditions."[4] This, however, does not exclude the possibility that *parts* of their different ranges may overlap, and that in certain regions they may be found together, and, moreover, a case in point has been described by me.[5] Thus it is evident that MacDougal has misunderstood me, and that he battles against a fancied idea, which, indeed, is disproved by the instance given (*Opuntia fulgida* and *mammillata*), and to which I am able to add numerous other examples of plants[6] as well as animals. But this does not influence my contention, *that closely allied species of plants or animals never possess precisely the same geographical range.*

With reference to Jordan's opinion that *Œnothera lamarckiana* might be a hybrid, which is also held by the present writer, MacDougal thinks that it possibly might be a good natural species. This question, however, is not essential for the interpretation of de Vries's experiments. The suggestion that it might be a hybrid, or the fact that, in Europe, it is an escaped garden-form, is advanced only to explain the remarkable variability of it. De Vries, assuming that it is as good as a natural species, tries to account for its wonderful capacity to throw off mutants, which is not generally found among natural species, by believing that there may exist, in any species, a time or period of especially vigorous and frequent mutation. But considering the fact that, in Europe, *Œnothera lamarckiana* is surely an escaped garden-form, and that it actually has been there under the care of florists for a long time, the possibility that it might be found in the wild state in America does not affect in the least degree the very tempting assumption that its strange behavior is due to cultivation with all its inherent and accessory incidents, exactly as is the case in other garden-forms.

MacDougal regards it as a specimen of "literary license" and "inaccuracy" (p. 213), when I say that de Vries entirely failed to take notice of the principle that the discovery of intermediate forms serves to show that two supposed true breeding forms do not possess the rank of species as understood by the taxonomist, and that he also failed to show that his so-called elementary species are not connected by intermediate forms. I do not see where the "license" and "inaccuracy" come in, for it is *a fact* that de Vries nowhere reported that he went over the whole area of any of the species used or referred to by him, and tried to ascertain whether there are anywhere such forms. Indeed, he reports that on rare occasions he found something which might be taken for connecting forms, but he never searched carefully and conscientiously for them. On the other hand, I know positively from my own experience that such forms do exist at least in some of the elementary species discussed by de Vries: I found them myself in nature in the group of *Viola tricolor* and *lutea*, and saw them in the case of *Draba verna* in de Bary's laboratory.[7]

As regards my "estimate of the futility of experimental methods" and my "mistrust" of them, MacDougal (p. 213) has not understood my standpoint. I have never said anything that might be construed as if I "mistrusted" experiments or believed them to be "futile"; on the contrary, I fully agreed that experiments ought to be made, but warned against too great complexity and improper interpretation.[8] I chiefly called attention to the complexity of conditions offered in cultures in the botanical garden, which is met by MacDougal (p. 213) by the statement that it is not the case, that "domesticated races" have resulted from the "effects of tillage." But, disregarding the fact that "tillage" is only one of the many factors contributing to the peculiar features of an environment in the garden, I never said that the effect of tillage (or any other environmental factor) is the production of "domesticated races." I attribute to the environment the power to influence "variation," but in order to obtain "domesticated races," that is to say, forms which breed true, I always insisted that pedigree-culture is necessary. In nature the analogous process, selection and segregation, leads to the formation of species.

II. It is possibly well to present here again my objections to de Vries's mutation theory, and, to further the correct understanding of my views, I shall try to represent the matter in a somewhat different form, emphasizing chiefly what are the undoubted facts, and what are their interpretations on the part of de Vries and on my part.

My first and fundamental contentions are:

1. *De Vries's conception of "elementary species" is inadequate.* There are, indeed, forms in nature which have a tendency to breed true, but which are not isolated from other forms, but these forms should not be called species. They have been called, for instance, by Darwin,[9] "varieties," and are distinguished by this quality from "variations." On the other hand, there are in nature true "species," characterized by the fact that the tendency to breed true is fully developed, and that there are no connecting links any more with allied forms: they are separated from the latter. This character furnishes a good definition for the term "species," which ought to be the taxonomic species. This, however, does not mean that in every case it should be easy or even possible to distinguish sharply between a variety and a species, since there are actual cases of transition in nature. Yet at the present state of our knowledge, the insufficiency of the latter alone prevents in many cases a final decision.[10]

2. *The essence of de Vries's experiments, pedigree-culture, consists of "selection" and "segregation."* This becomes most evident in MacDougal's description of his methods as given in the paper under discussion (p. 214 f.), and anybody may see at a glance that MacDougal, as well as de Vries, did nothing that has not the purpose of selecting certain variations and their seeds, and of segregating (separating) them from disturbing influences.

Granting that these fundamental views are correct, we may now look at the bare facts represented in de Vries's experiments, without any attempt at explanation or theoretical speculation. The following two stand out prominently:

1. *By pedigree-culture de Vries succeeded in making certain variations breed true.*

2. *In other cases of variations he did not succeed.*

The first sentence tells an old story. The same has been done since time immemorial, and scientific investigation has taken notice of this fact since the time of Darwin. The process is now rather well understood, that is to say, with reference to the essential features of the action required of man; they are selection and segregation. De Vries did not change the old method in the slightest degree, he only introduced additional precaution and refinement in detail, taking particular pains to insure the full efficiency of these two factors by carefully excluding all possible interference with them. In addition he was the first to keep proper scientific records of what he was doing.

The second fact, on the contrary, is new, and it is the point in de Vries's experiments which needs explanation and a theory. Why is it that certain variations did not breed true under de Vries's hands, although they were treated exactly like those belonging to the first group? The general belief, up to this time, was that any variation might be transformed into a true breeding form by proper treatment.

De Vries's explanation of this fact is given in his mutation theory. Believing that his experiments are conclusive, and that, since he himself did not succeed in cases of the second group, *nobody would be able to do so*, he propounds the theory that there are actually certain variations, in which selection and segregation (pedigree-culture) are impotent to produce true breeding, and, consequently, that there are two classes of variations, the one of which he calls "mutation," which produces forms which respond to the effort of the breeder, the other in which the art of the breeder has no effect, and which he calls "fluctuating variation." Then the first is, of course, all important for the species-forming process, while the other is of no consequence. There is no saying, with respect to any particular variation, whether it may belong to the one or to the other class, before the actual test (pedigree-culture) has been made, although it seems that mutations often or generally differ from fluctuating variations in the degree of deviation from the original form. This is the essence of the mutation theory.

The above conclusion and theory would be perfectly correct, if the proposition was correct that it is actually impossible to make certain variations breed true. But just in this point, I believe, de Vries is wrong, since his experiments were not conducted in such a way as to absolutely preclude the possibility that even so-called "fluctuating variations" may be successfully transformed into true breeding forms. We always are to bear in mind that it is at least thinkable that a particular form may be bred true only under particular conditions, under conditions which are congenial or essential to its very existence. To present an imaginary example: a plant species may possess a peculiar variation, which is due to lack of direct sunlight (shade-form). Suppose this shade-form is cultivated according to de Vries's method in the botanical garden, in beds where it gets its full share of sunlight. I never believe, in such a case, that pedigree-culture will succeed in making this shade-form breed true, since always the conditions of environment will have the tendency to paralyze the effort of the breeder. If, however, this particular shade-form is bred in the shade, under proper environment, the attempt possibly may not be in vain.

This is only an example to illustrate what I think may be correct. Every plant breeder knows that many of our garden forms will come true only when treated in a certain way. These various ways, including everything that comes under the head of gardener's "tricks," are familiar to the professional and amateur,[11] and their results are regarded among laymen as due to a "lucky hand." Pure strains of seed, of course, obtained by pedigree-culture, are the first condition, but pedigree-culture is not all of the secret, since the proper handling of the seeds is also material, as well as the observation of certain "tricks" with the growing plants, *which have no other object but to furnish the congenial environment to the object.*

I think that any one who has ever done actual garden work, trying to raise particular strains of flowers or vegetables, will understand what I mean by these "tricks." This essential element is obviously lacking in de Vries's experiments: he uniformly bred all his

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[1] "Discontinuous Variation in Pedigree-Culture," Pop. Sci. Monthly, 69, Sept., 1906, pp. 207-225.

[2] See Jordan's rejoinder in Science, September 28, 1906, p. 399.

[3] We always are to remember that, strictly speaking, there is no morphological difference between fluctuating variation and mutation; the latter can only be recognized by experiment, according to de Vries, and also MacDougal. Thus it is not correct to talk, as MacDougal does, of mutation as a synonym of discontinuous variation. A mutation may be due to discontinuous variation, and, as de Vries declares, generally is, but not always. In this respect, MacDougal, in the article referred to, certainly goes beyond de Vries. If this is borne in mind, it is clearly seen that Merriam's objection does not affect at all de Vries's theory as a whole, but only the part of it that says that discontinuous variation or saltation is a necessary or frequent attribute of mutation (in the sense of creating the faculty to become a true breeding form).

[4] Science, June 22, 1906, p. 949.

[5] Science, March 30, 1906, p. 504.

[6] For instance, *Orchis ustulata* and *tridentata*, two closely allied species, but of quite different aspect, grow side by side (forming hybrids) upon the meadows of the valley of the river Saale, near Jena, Germany; on a certain hillside near Jena, *Ophrys muscifera* and *aranifera* grow together (also forming a hybrid).

[7] See also: Stone, W., in Science, May 4, 1906, p. 701, with reference to *Viola*.

[8] Science, June 22, 1906, p. 952.

[9] Darwin, "Origin of Species," p. 33.

[10] See Pr. Amer. Philos. Soc., 35, 1896, p. 191.

[11] For those who have no practical experience in gardening, the study of a few items in Bailey, "The Cyclopedia of American Horticulture," will give an idea of the immense variety of these tricks.

mutants "in the botanical garden," and "in well-manured soil," and apparently also under the same conditions of climate, season, subsoil, insolation, etc., that is to say, under a uniform set of ecological conditions, such as are generally found in a botanical garden. Indeed, it has been questioned that a change of these conditions may influence the true breeding of a strain, but without sufficient reason, since such an assumption is surely unwarranted as long as the question has not been actually tested in a scientific way. The necessity, in certain cases, to observe certain "gardener's tricks," in order to get the best results in raising particular races, strongly favors the opinion that environment actually has something to do with it, and scientific experiments with this in view should be made by all means. Where de Vries succeeded in breeding true his "mutations," the environment of the botanical garden was not averse to the experiment, and in this connection it is suggestive that his chief success was attained with *Œnothera lamarckiana*—an escaped garden-form, to which apparently the botanical garden was congenial.[12]

Finally, in order to define my standpoint as precisely as possible, and in order to obviate unnecessary discussion of minor and irrelevant points, I shall condense everything I have said into five questions, and if anybody wants to challenge my propositions, I ask him to do so in terms as laid down here.

1. *Does the "elementary species" of de Vries correspond to Darwin's conception of "variety," and is my definition of "species" ("taxonomic species") acceptable?*

2. *Are selection and segregation the essential features in pedigree-culture?*

3. *Are de Vries's experiments, aside from their greater accuracy and refinement, essentially identical, in their method, with those of the earlier breeders, as, for instance, recorded by Darwin?*

4. *Is it advisable that breeding experiments should be repeated with due regard to environment, before a final judgment is to be pronounced, and are de Vries's experiments defective on this point?*

If the answer to these four questions is "*Yes*," then my contentions are recognized as well supported, and the answer to the next question should also be "*Yes*"—

5. *Should the validity of de Vries's mutation theory be doubted, since he makes an unwarranted distinction between two kinds of variation, which further experiments possibly will prove to be identical?*

If, however, anybody should be inclined to answer "*No*" to any or all of these questions, I ask him to give *reasons* for so doing. I have given my reasons for answering them in the affirmative; consequently, it should be demonstrated that my reasons are no good. Nobody ever attempted this, and when arguments were given purporting to be opposed to my ideas, these invariably were not my views, but only what the critic fancied to be my views.[13]—Science.

WHITE ANTS.

WHITE ants are a never-ending trouble to the Australian settler. From the earliest period of the white man's residence on the shores of Botany Bay the fragile little creature has waged a continuous war against him by attacking, dismantling, and in many cases devouring the most cherished of his possessions—his house. Before the white man's advent houses were unknown. The aborigines of the vast territory knew nothing of such structures, a few sheets of bark constituting the shelter they temporarily required. But even then the white ants abounded. They ate the standing trees in the forest; they devoured fallen branches; they made nests in logs and roots. From Port Darwin to the south of New South Wales evidences of their activity in far-off times exist in the remains of huge mounds, the labor of millions upon millions of the tiny insects. With civilization and house-building came new spheres for their activity. Wherever woodwork was used, in city center or bush hut, the creature had to be guarded against, and the utmost care and precaution were often futile in the contest. Buildings in the capitals have had to be remodeled and sometimes taken down because of the extent of the ravages. A building in the country known to be affected with white ants becomes practically unsalable. Occasionally the affected board or joist or several affected ones are removed and sound timber introduced, in the hope of making good the injury; but rarely does such patching avail.

The white ant is an unseen worker. It may have secured a lodgment in a house many years back; generations of the creature may have lived and worked and died without creating by sound or otherwise the slightest suspicion of their presence; and it is only when they have consumed the entire substance underneath that the shell of the wood falls in and disaster is revealed. Governments have spent tens of thousands of pounds experimenting with preventives, and individuals have expended even more; but the white ant is now as much a master of the situation as at any time in the past.

It may be necessary to say that the insect, though popularly known as a white ant, is from a naturalist's point of view not an ant at all. It belongs to the *Termitidæ* group, with distinct habits and a distinct life-history. It is only about forty years since it was taken up as an object of serious study; but in that short time there has accumulated about it a literature valuable to the naturalist, and interesting—however painfully so—to all who directly or indirectly come within the sphere of the creature's operations.

It is a tiny creature, about a quarter of an inch in length, and so slight that even a gentle touch of the fingers squashes it. The community has three bodies: the queen, workers, and soldiers. The life of the nest centers in the queen. She is larger, many times larger, than any of the workers or soldiers, and several cells near the foundation of the nest are placed at her disposal. In these cells she deposits eggs, and to the preservation of her and her eggs the tireless industry of the community is directed. The soldiers literally represent men under arms. They stand about the passage or openings as if at attention. They closely observe all that goes on, but do no menial or laboring work. The food is carried in and the litter carried out, but the soldiers lend no assistance to either batch of workers. Strike the nest, however, with a stick, and they will promptly rush to the spot. Make an opening, and they will stand in the aperture and menacingly snap their jaws together. When the assaulting enemy has gone away they supervise the repairing of the damage done.

These ants build in the most dissimilar places. At the root of a tree, in the branches, under a heap of stones, on the barren plain, on the floor or roof or mantelpiece of a dwelling, the pulpit or altar of a cathedral, or in the columns or cupolas of public buildings, white ant nests may be found. They may tunnel underground, showing no visible indication of their existence, or build mounds eighteen or twenty feet high, challenging the attention of all who pass; but wherever they live they are equally obnoxious to man and his works. It was at one time thought that far off in the bush they existed on decayed vegetable matter, and thus performed a natural service in freeing the plains from litter. But experience shows that they have no special liking for decayed timber; rather, in many situations, it has been proved that they passed by decayed in favor of sound wood. Sound soft wood such as deal is most to the white ant's taste; but sound hardwood, even ironbark, it will tunnel long distances to reach. Its instinct for finding nutritious food leads it long journeys from home. Through four or five inches underground it will bore in a straight line, if the soil permits, to a standing pine or tallow wood; and if a rock obstruction intervene, it will turn the corner by the shortest curve and go straight for its object. When it finds the distance too far for a day's journey it constructs depots midway, or a fresh colony is formed.

The great mounds that are so common a feature of Australian scenery are beginning to excite the interest they deserve. These white ant nests are among the marvels of insect architecture. In various parts of New South Wales, in Queensland, and the northern territory of South Australia, mounds up to twenty feet high and a dozen feet in circumference may be met. They look like the work of man, though their purpose would puzzle the most resourceful. A few early observers judged them to be tombs of members of the black race, or monuments to commemorate important incidents. When their origin and use were settled, the reason for heaping them up so high became the tantalizing question. That question must remain unsolved for some time yet. The lofty structure exposes the inhabitants of the nests to the assaults of enemies. The white man, as settlement advances, clears them out of his way. He finds that the material of the nest makes a very good substitute for cement as a floor for his bush hut. It takes some labor to break the stuff up; but when broken up and pounded together it is almost watertight and proof against the teeth of rats and mice. Before the advent of the white man, the mound, seen at a distance, attracted, and even yet attracts, the hungry black man. He rather likes white ant as a repast. It satisfies hunger and stimulates him, owing to certain ginger-like properties the food possesses. A few black fellows will devour a million of the insects in a day, and were the mounds less difficult to smash up the repast would be more frequently enjoyed.

But the height of the mounds is not the only perplexing feature of this architecture of the creatures. One family builds a nest so that the long axis runs north and south. The nest has, therefore, its sides exposed to east and west. That insect is known as the compass or magnetic ant; and the only explanation available of its peculiar building habit is that by offering the sides to east and west it exposes the largest possible area to the tropic sun; and this, in regions where heavy, saturating rains are frequent, enables the architect to obtain a dry home in the shortest time. A study of the habits of insects reveals so many subtle adaptations to natural surroundings that one is not astonished even at this claim.

A white ant exterminator has been the dream of many inventors. There is no doubt that where a nest is built in an accessible spot, and the underground avenues can all be commanded, extermination of a particular colony is possible. It has actually taken place under the writer's observation. The bed was dug up and the ground around a radius of fifty feet turned up and trenched, and a liquid mixture of washing soda and arsenic poured over. Usually, however, when ants are discovered, it is too late to apply this drastic treatment. The ants may be already in the house or building, or they may be carried in in the next load of wood cut for the fire, or they may come home in a walking stick. At the swarming season they may even fly on to the roof or make their way through the windows. Thus, extermination in the manner stated does not afford complete security if white ants exist anywhere in the neighborhood. Of course, comparative security is worth striving for, and consequently almost every one in ant-infested country exterminates where he can, and adopts every preventive within his reach. In many parts the houses are built on blocks capped with zinc, and salt and tar and a number of other ingredients supposed to be odious to the insects are spread about.—Chambers's Journal.

[12] I call attention to Jordan's account of some of Burbank's experiments (in Pop. Sci. Monthly, January, 1905), where also the influence of the environment in the production of variation is repeatedly emphasized, chiefly on pages 205 and 206. Possibly, if Burbank's attention is called to it, he may be able at once to quote instances where the true breeding of a certain strain depends largely on the environment offered. This, of course, should be the general rule, but it can be clearly observed only in such cases where a particular feature of the environment is known to be responsible for a particular variation.

[13] See also my reply to Gager's criticism in Science, August 17, 1906, pp. 214-217.

SCIENCE NOTES.

Affinity was first considered as a force, and in this direction it was natural to think of the Newtonian attraction as the chemical agent. So it was that Berthollet, and with far more success Guldberg and Waage, applied the laws of mass action to problems of chemical affinity, formulating a relation still known as the mass law, according to which affinity is proportional to the weight in the unit of volume. Now, as we all know, chemical affinity is of a specific nature, and does not depend on weight merely; on the contrary, the least heavy elements are generally the most active. So Berzelius built up his system founded on the notion that elements have a specific electrical character, either positive or negative, and, in combining, act by electrical attraction. In this direction Helmholtz made a further step in taking into account the quantitative side. Considering the electrical charges involved in Faraday's law, he pointed out as very important that the attraction due, for instance, to the negative charge in chlorine and the positive one in hydrogen far exceeds the gravitational attraction of the masses. Yet a satisfying notion of affinity was not obtained in this way.

In reviewing the measures of sun-spots for the year 1905 from photographs taken at Greenwich, Dehra Dun, Kodaikanal, and Mauritius, the Astronomer Royal states that there was a marked increase over the area for 1904, both the umbræ and the whole spots showing an increase of over 144 per cent, the actual area of 1191 being greater than that of 1883. Three periods of exceptional activity were noticeable, comprising January to March, July and October to November. The faculæ, as usual, maintained a more steady rate of advance than the spots, the total for the whole year only showing an increase of 48 per cent over that for 1904. The two hemispheres showed different activities in the ratio of 63 to 37, for the north and south respectively. As the mean distance from the equator of all spots barely exceeded 13 deg., this is suggestive that 1905 was the actual year of maximum of the present cycle. Also every latitude from the equator up to 32 deg. was represented, this being an arrangement usually characteristic of the year of maximum activity. The most striking feature of the year was the great number of abnormally large spot groups, notably that of January 29 to February 11, 1905.

In a description of the new three-horned dinosaur, a model of which is being set up in the Natural History Museum, South Kensington, Mr. R. Lydekker quotes in Knowledge a description of a fight between two reptiles of this kind. The Triceratops had three horns and the largest head of any known land animal either living or dead. So long as this three-horned monster faced an adversary he must have been practically invulnerable, but, as he was the largest animal of his time, it is probable that his combats were mainly with those of his own kind, and the subject of dispute some fair female upon whom rival suitors had cast covetous eyes. What a sight it would have been to have seen two of these big brutes in mortal combat as they charged upon each other with all the impetus to be derived from 10 tons of infuriate flesh! We may picture to ourselves horn clashing upon horn, or glancing from each bony shield until some skillful stroke or unlucky slip placed one combatant at the mercy of his adversary. A pair of Triceratops horns in the National Museum (at Washington) bears witness to such encounters, for one is broken midway between tip and base; and that it was broken during life is evident from the fact that the stump is healed and rounded over, while the size of the horns shows that their owner reached a ripe old age.

That the bogs of Ireland would furnish an unlimited supply of peat, and that peat will furnish alcohol, is one of the suggestions made in Knowledge by Mr. C. Ainsworth Mitchell, F. I. C. A few years ago the problem of obtaining fermentable sugar on a commercial scale from sawdust was successfully solved, and experiments on similar lines with peat as the raw material have recently given promising results. It is well known that when starch is treated with a dilute acid it is converted into sugars and dextrins which can be more or less completely fermented by yeast, and a similar change can be effected, though less completely and with more difficulty, by the action of acid upon cellulose, which forms a chief constituent of both sawdust and peat. Ordinary peat containing about 62 per cent of water was boiled for fifteen minutes with dilute sulphuric acid in a closed copper vessel under a pressure of three atmospheres, after which the mass was expressed under moderate pressure, and the filtrate neutralized with chalk and separated from the resulting gypsum. It was then fermented in large tuns with a special yeast and a portion of the alcoholic product distilled. The distillate contained 5½ per cent of alcohol corresponding to a

total calculated yield of 75½ liters of absolute alcohol from 225 kilos of peat. A systematic study of the effect of varying the conditions as to the amount and concentration of the acid, the time of treatment, and the pressure will probably lead to a process which shall produce a stronger saccharine solution, and consequently, a "wash" richer in alcohol.

ENGINEERING NOTES.

The recent annual droughts in some of the mountainous coal-mining districts of the United States, where the river waters have become badly contaminated and polluted by the refuse from mines, mills, and decaying animal and vegetable matter, has resulted not only in scarcity of supply, but in a water that is entirely unfit for locomotive purposes, the consequence of which has been an unlimited expense and delay in the handling of power and traffic.

With the rapid spreading of industries at this time, it is wise to design power plants with a view to prospective rather than to immediate earnings. Therefore, comparisons of the cost of different types of plants are not only for the most part inaccurate, but are also of local and momentary value. Earning capacities depend on the market for the output. Markets commend the employment of the most economic methods of fuel transformation, utilization and conservation, rather than the adoption of methods which appear to secure the maximum immediate profit. This question of the economic relation of a gas to a steam plant has passed into an entirely new phase since it became possible to directly gasify such fuels as cannot be efficiently used for raising steam under boilers. This brings us to the other important factor in the evolution of gas power, namely, the producer, which has helped to conquer for the gas engine the enormous and practically unlimited field of application which it is just beginning to enjoy.

The performance of the motor boat "Hazel," described in a recent number of the SCIENTIFIC AMERICAN, is in many ways an extraordinary one. The craft was launched April, 1905, and on her maiden trip passed down the Chesapeake Bay around the Capes and up the coast, outside, to Ocean City, N. J., where she remained for the rest of the summer. In August the "Hazel" towed six yachts of the Ocean City Yacht Club to Seaside Park for the Labor Day races, covering fifty miles in eight hours. Of the tow, no yacht was under 30 feet in length. The "Hazel" then left for New York to enter the races in the Motor Boat carnival, September, 1905, and covered the 6½-knot course three times at the rate of 9½ miles per hour, and despite an accident in striking a submerged barrel came in second in her class, after a race remarkable for steady running. The boat returned to Philadelphia after the races, where her bottom was coppered, and she then started south in December to a point 50 miles below Miami. Last spring the "Hazel" ran up the coast to Essington, Pa., and subsequently went to Newport, R. I., for the summer. In September she returned to New York, and went up the Hudson to Albany, thence through the Erie Canal to Buffalo, and through the Great Lakes during November and December to Chicago. From Chicago to St. Louis she was shipped by rail, owing to the prevalence of ice in the waterways, and the same cause prevented launching at St. Louis, and she was therefore shipped to Cairo, Ill. From the latter point the "Hazel" ran down the Mississippi to New Orleans, thence to Mobile, Pensacola, Apalachicola, and at the present time is at Tampa Bay, Fla., having covered to date over 15,000 miles in twenty-three months with practically no breakdowns or repairs beyond the replacement of the exhaust pipe. The "Hazel" is 46 feet over all, with a beam of 10 feet 6 inches and a draft of 3 feet. She has a 25-horse-power "Crown" yacht engine of four cylinders, 6¼ x 7 inches. The motor drives a three-blade propeller at the rate of 400 revolutions per minute. The propeller is 30 inches in diameter with a 36-inch pitch and has 9-inch blades. The auxiliary sailspread is 635 square feet. The original cost, excluding sail, spars, and cabin furnishings, was $4,000. The engine is worked by turning a switch in the cockpit, from which point the craft is steered and handled. She is a one-man boat in every respect, and in the very heaviest weather has fully demonstrated her seaworthiness.

Few subjects which are to-day engaging the attention of the engineering world are comparable either in scientific interest or in practical importance to the substitution of the electric motor for the steam locomotive engine. On the Valtellina line and through the Simplon tunnel 70-ton electric locomotives, with three-phase motor equipment, capable of developing a draw-bar pull of 28,000 pounds, have displaced the steam locomotive, with results showing both marked improvement in service and substantial economy in operating costs. In the New York Subway, eight-car trains weighing 320 tons are in operation, equipped with motors developing during acceleration a tractive effort equivalent to a draw-bar pull of 55,000 pounds. The heaviest passenger locomotive used on the Erie system weighs, exclusive of tender, 206,000 pounds, of which 55.8 per cent, or 115,000 pounds, is effective on drivers. Assuming the adhesion to be 20 per cent, such a locomotive exerts a draw-bar pull of 23,000 pounds. The motors of the eight-car electric train of the New York Subway, therefore, exert a tractive effort equivalent to more than twice the draw-bar pull of this locomotive.—Extract from address by Lewis B. Stillwell and Henry St. Clair before the American Institute of Electrical Engineers.

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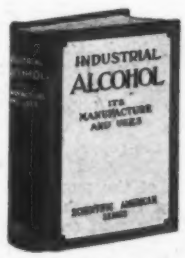

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